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THIRTY-EIGHTH ANNUAL REPORT

of

Forage Research

in the

Northeastern United States

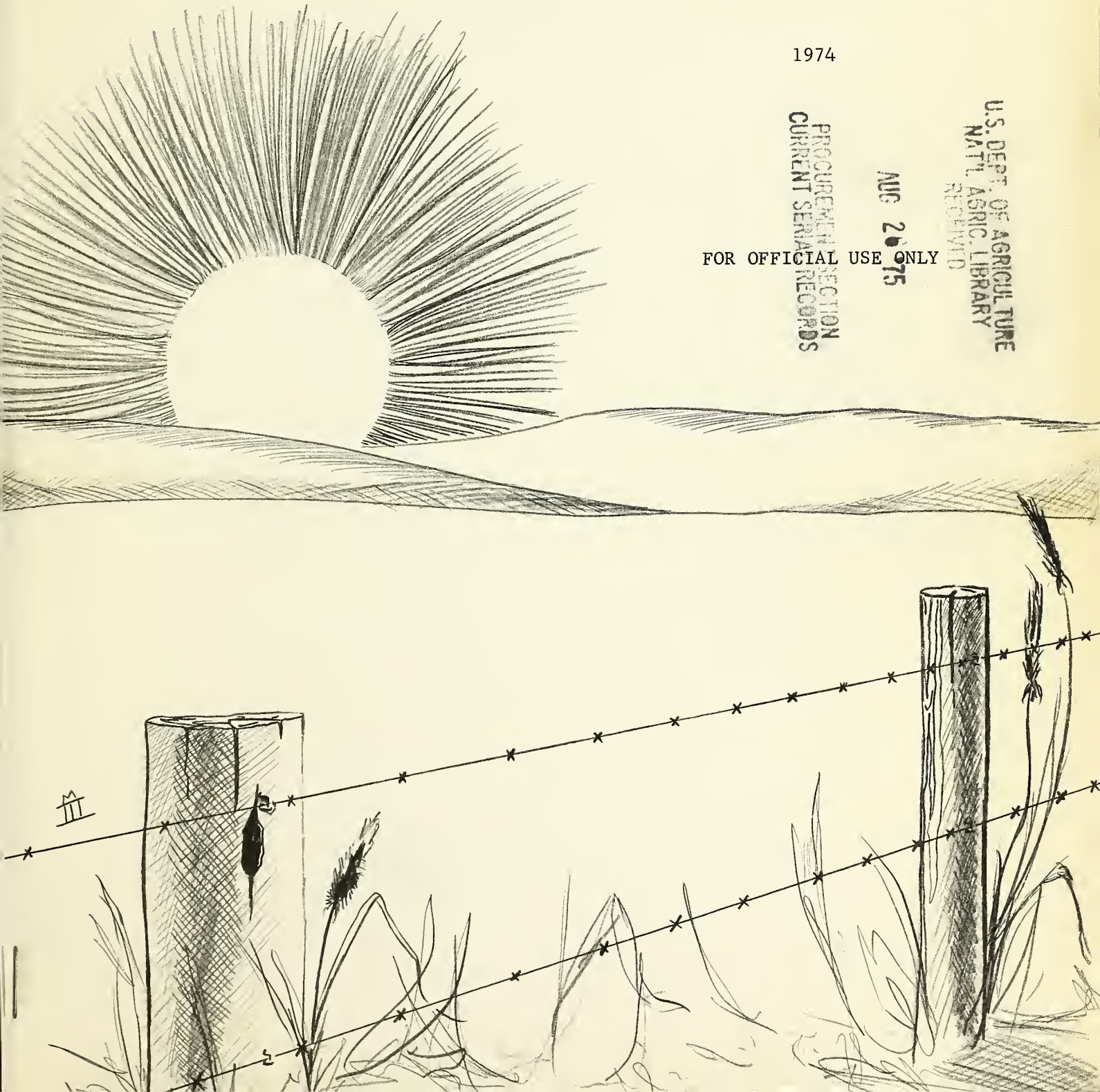
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1974

Thirty-Eighth Annual Report  
of  
Forage Research  
in the  
Northeastern United States

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A Joint Contribution of the  
U.S. Regional Pasture Research Laboratory  
and the  
Agricultural Experiment Stations  
of the  
Twelve Northeastern States

---

Participating Agencies

Beltsville Agricultural Research Center,  
Chesapeake-Potomac Area, and  
North Atlantic Area  
of the Northeastern Region  
Agricultural Research Service, U.S. Department of Agriculture  
and the

Agricultural Experiment Stations of

Connecticut (Storrs)	New York (Cornell)
Delaware	New York (Geneva)
Maine	Pennsylvania
Maryland	Rhode Island
Massachusetts	Vermont
New Hampshire	West Virginia
New Jersey	

\* \* \* \* \*

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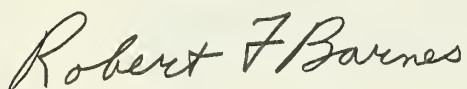
## PREFACE

This Annual Report is intended primarily for use by forage research and extension workers in the Northeastern United States. It contains brief reports of research projects carried on at most of the State Agricultural Experiment Stations in the region. It also includes reports from research personnel of the Northeastern Region, Agricultural Research Service, U.S. Department of Agriculture. Our appreciation is extended to all contributors and to the contact person at each station who coordinated the collection of reports.

Over 130 reports were received which involved more than 150 scientists. The reports are divided topically into various sections. For convenience an author index has been prepared. A roster is included of research and extension workers in the Northeastern United States who devote at least a portion of their time to forage and grassland research or extension activities. Publications appearing since the last report and names of individuals receiving their advanced degrees in 1974 are listed.

A Technical Steering Committee was established during 1974 for the development of a Forage Research Program for the Northeast. Present activities of the Steering Committee include the assessment of current research efforts in the region and identification of specific researchable problems and goals. Considerable progress is anticipated during the next year in the development of a plan of action for implementing research needs in the future. The significance and importance of the contributions of individual scientists in this effort cannot be overemphasized.

Your comments and suggestions on how this Annual Report might be made more accurate and relevant in the future would be appreciated.



Robert F. Barnes  
Laboratory Director

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Roster of Research and Extension Workers in the Northeastern  
United States with Some Forage Crops and Grasslands Orientation

<u>Name</u>	<u>Field of Interest</u>	<u>Department</u>
<u>University of Connecticut</u>		
Storrs 06268		
Allinson, D. W.	Forage Management	Plant Science
Cowan, W. A.	Animal Nutrition	Animal Industries
Dest, W. M.	Weed & Turf Investig.	Plant Science
Griffin, G. F.	Soil Fertility	Plant Science
Peters, R. A.	Weed Investigations	Plant Science
Washko, W. W.	Forage Management	Plant Science
Wengel, R. W.	Soil Physics	Plant Science
<u>University of Delaware</u>		
Newark 19711		
Crittenden, H. W.	Legume Diseases	Plant Science
Fowler, R. E.	Beef Cattle Nutrition	Animal Sci. & Agric. Biochemistry
Haenlein, G. F. W.	Nutritive Evaluation	do.
Jones, E. R.	Forage Management	Dept. of Agriculture Delaware State College Dover, Del. 19901
Mitchell, W. H.	Forage Management	Plant Science
Reitnour, C. M.	Horse Physiology	Animal Sci. & Agric. Biochemistry
Svec, L. V.	Physiology	Plant Science
<u>University of Maine</u>		
Orono 04473		
Apgar, W. P.	Forage Utilization	Animal & Veterinacy Sci.
Brown, C. S.	Forage Management	Plant & Soil Sciences
Forsythe, H. Y., Jr.	Forage Insects	Entomology
Holyoke, V. H.	Silage Corn Management	Plant & Soil Sciences
Rowe, R. J.	Engineering Harvesting	Agricultural Engineering



<u>Name</u>	<u>Field of Interest</u>	<u>Department</u>
<u>University of Maryland</u>		
College Park 20742		
Burt, G. W.	Weed Control	Agronomy
Clark, N. A.	Forage Management	Agronomy
Decker, A. M., Jr.	Forage Management	Agronomy
Harris, W. L.	Agric. Engineering	Agricultural Engineering
Leffel, E. C.	Animal Science	Animal Science
Morgan, O. D., Jr.	Plant Pathology	Botany
Parochetti, J. V.	Weed Control	Agronomy
Vandersall, J. H.	Dairy Science	Dairy Science
<u>University of Massachusetts</u>		
Amherst 01002		
Fenner, Heinrich	Animal Nutrition	Vet. & Animal Sciences
Mudgett, R.	Food & Agric. Eng.	Engineering (Food & Agric.)
Vietor, Donald	Plant & Soil Science	Plant & Soil Science
Whitney, L. F.	Agric. Engineering	Engineering (Food & Agric.)
<u>University of New Hampshire</u>		
Durham 03824		
Byers, G. L.	Agric. Engineering	Water Resources Res. Center
Dunn, G. M.	Genetics	Plant Science
Estes, G. O.	Forage Nutrition	Plant Science
Holter, J. B.	Animal Nutrition	Animal Sciences
Koch, D. W.	Forage Plant Physiol.	Plant Science
Mitchell, J. R.	Forage Management	Plant Science
O'Connor, J. T.	Animal Science	Animal Sciences
Peirce, L. C.	Genet. Hort. Crops	Plant Science
Routley, D. G.	Plant Chemistry	Plant Science
<u>Rutgers University, The State</u>		
<u>University of New Jersey</u>		
New Brunswick 08903		
Duell, R. W.	Highway Vegetation	Soils and Crops
Evans, J. L.	Nutritional Value	Animal Science
Halisky, P. M.	Plant Pathology	Plant Biology
Ilnicki, R. D.	Weed Control	Soils and Crops
Mears, D. R.	Agric. Engineering	Engineering
Race, S. R., Jr.	Forage Insects	Entomology & Economic Zoology



<u>Name</u>	<u>Field of Interest</u>	<u>Department</u>
<u>Rutgers Univ. (Cont.)</u>		
New Brunswick 08903		
Ramage, C. H.	Production Utilization	Animal Science
Singley, M. E.	Engineering, Utilization	Engineering
Sprague, M. A.	Management, Preservation	Soils and Crops
Vander Noot, G. W.	Forage Utilization	Animal Science
 <u>Cornell University (New York)</u>		
Ithaca 14853		
Campbell, J. K.	Agricultural Engineering	Agricultural Engineering
Duke, W. B.	Weed Control	Agronomy
Fick, G. W.	Forage Physiol & Manag.	Agronomy
Grunes, D. L.	Soils & Plant Nutr.	U.S. Plant, Soil and Nutrition Lab.*
Gyrisco, G. G.	Entomology	Entomology
Helgesen, R. G.	Entomology	Entomology
Linscott, D. L.	Weed Control	Agronomy
Lowe, C. C.	Genetics & Breeding	Plant Breed. & Biometry
Lucey, R. F.	Forage Management	Agronomy
Millar, R. L.	Plant Pathology	Plant Pathology
Millier, W. F.	Agricultural Engineering	Agricultural Engineering
Murphy, R. P.	Genetics and Breeding	Plant Breed. & Biometry
Pardee, W. D.	Forage Management	do.
Reid, J. T.	Animal Nutrition	Animal Science
Schaaf, H. M.	Genetics and Breeding	Plant Breed. & Biometry*
Seaney, R. R.	Forage Management	Agronomy
Van Soest, P. J.	Animal Nutrition	Animal Science
Wright, M. J.	Forage Management	Agronomy
 <u>New York State Agricultural</u>		
<u>Experiment Station</u>		
Geneva 14456		
Braverman, S. W.	Plant Pathology	Seed Investigations and ARS-USDA
Dolan, D. D.	Plant Introduction	do.
Sherring, W. R.	Seed Technologist	Seed Investigations

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\* USDA-ARS Cooperative appointment.

<u>Name</u>	<u>Field of Interest</u>	<u>Department</u>
<u>The Pennsylvania State Univ.</u>		
University Park 16802		
Ace, D. L.	Dairy Extension	Dairy Science
Adams, R. S.	Dairy Extension	Dairy Science
Bartlett, H. H.	Agricultural Engineering	Agricultural Engineering
Baumgardt, B. R.	Animal Nutrition	Animal Science
Baylor, J. E.	Pasture and Forage Crops (Extension)	Agronomy Extension
Bloom, J. R.	Nematode Control	Plant Pathology
Burdette, L. A.	Animal Nutrition Ext.	Animal Science
Cash, E. H.	Animal Nutrition	Animal Science
Cleveland, R. W.	Genetics and Breeding	Agronomy
Cowan, R. L.	Animal Nutrition	Animal Science
Downs, W. G.	Forage Management	Agronomy (P.O. Rector)
Dum, S. A.	Farm Management Ext.	Economics
Guss, S. B.	Veterinary Sci. Ext.	Veterinary Science
Hartwig, N. L.	Weed Control	Agronomy
Hershberger, T. V.	Animal Nutrition	Animal Science
Hower, A. A., Jr.	Forage Insects	Entomology
Johnson, M. W.	Corn Breeding	Agronomy
Kardos, L. T.	Soil Physics	Agronomy
Kesler, E. M.	Dairy Science	Dairy Science
Kjelgaard, W. L.	Agricultural Engineering	Agricultural Engineering
Knieval, D. P.	Forage Physiology	Agronomy
Kradel, D. C.	Veterinary Medicine	Veterinary Science
Long, T. A.	Animal Nutrition	Animal Science
Lukezic, F. L.	Forage Pathology	Plant Pathology
Marriott, L. F.	Soil Fertility	Agronomy
McKee, G. W.	Ecology, Physiology	Agronomy
Merritt, T. L.	Animal Science	Animal Science
Partenheimer, E. J.	Agricultural Economics	Agricultural Economics and Rural Sociology
Risius, M. L.	Genetics and Breeding	Agronomy
Shenk, J. S.	Forage Grass Breeding	Agronomy
Starling, J. L.	Genetics and Breeding	Agronomy
Thomas, W. I.	Representative NE	Agric. Exp. Station
Wangsness, P. J.	Animal Nutrition	Animal Science
Washko, J. B.	Forage Management	Agronomy
Wilson, L. L.	Animal Science	Animal Science
Yendol, W. G.	Non-Pesticide Insect Control	Entomology

University of Rhode Island  
Kingston 02881

Henderson, B. W., Jr.	Animal Nutrition	Animal Science
Wakefield, R. C.	Management	Plant and Soil

<u>Name</u>	<u>Field of Interest</u>	<u>Department</u>
<u>University of Vermont</u>		
Burlington 05401		
Gotlieb, A. R.	Plant Pathology	Botany
MacCollom, G. B.	Entomology	Entomology
Smith, A. M.	Animal Nutrition	Animal Sciences
Welch, J. G.	Nutritional Value	Animal Sciences
Wood, G. M.	Forage & Turf Manag.	Plant & Soil Science
 <u>West Virginia University</u>		
Morgantown 26506		
Anderson, G. C.	Animal Nutrition	Animal & Vet. Sciences
Baker, B. S.	Forage Management	Allegheny Highlands Project, Elkins, W.Va.
Balasko, J. A.	Forage Physiology	Plant Sciences
Bennett, O. L.	Forage Management	Plant Sciences & ARS-USDA
Butler, Linda	Entomology	Plant Sciences
Diener, R. G.	Agricultural Engineering	Resource Management
Elliott, E. S.	Root Diseases	Plant Sciences
Horvath, D. J.	Animal Nutrition	Animal & Vet. Sciences
Keefer, R. F.	Soil Fertility	Plant Sciences
Pohlman, G. G.	Soil Fertility	Plant Sciences (Emeritus)
Reid, R. L.	Animal Nutrition	Animal & Vet. Sciences
Thomas, R. O.	Dairy Nutrition	do.
Toben, G. E.	Agricultural Economics	Resource Management
Ulrich, V.	Plant Breeding	Plant Sciences
Veatch, Collins	Weed Control	Plant Sciences (Emeritus)
 <u>Beltsville Agricultural Research Center</u>		
Northeastern Region, Agricultural Research Service		
U.S. Department of Agriculture		
Beltsville, Md. 20705		
Adams, J. R.	Res. Entomologist	Insect Pathology Lab
Armiger, W. H.	Res. Agronomist	Biological Waste Manage- ment Lab
Bond, J.	Res. Animal Scientist	Ruminant Nutrition Lab
Cantwell, G. E.	Res. Entomologist	Insect Pathology Lab
Carlson, G. E.	Res. Agronomist	Light & Plant Growth Lab
Chatterton, N. J.	Res. Plant Physiol.	Light & Plant Growth Lab
Coulson, J. R.	Res. Entomologist	Beneficial Insect Introduc- tion Lab
Dinius, D. A.	Res. Animal Scientist	Ruminant Nutrition Lab
Dudley, R. F.	Agricultural Eng.	Physical Control Lab



<u>Name</u>	<u>Field of Interest</u>	<u>Department</u>
Beltsville Agricultural Research Center (Cont.) Northeastern Region, Agricultural Research Service U.S. Department of Agriculture Beltsville, Md. 20705		
Elgin, J. H., Jr.	Res. Agronomist	Field Crops Lab
Faust, R. M.	Res. Entomologist	Insect Pathology Lab
Feldmesser, J.	Zoologist	Nematology Lab
Foote, R. H.	Agric. Administrator	Systematic Entomology Lab
Foy, C. D.	Soil Scientist	Plant Stress Lab
Garrison, C. S.	Supvry. Res. Agronomist	Seed Quality Lab
Goering H. K.	Res. Animal Scientist	Ruminant Nutr. Lab
Goodwin, J. S.	Res. Entomologist	Insect Pathology Lab
Graham, J. H.	Res. Plant Pathologist	Plant Stress Lab.
Heimpel, A. M.	Res. Entomologist	Insect Pathology Lab
Hill, K. R.	Res. Chemist	Analytical Chem. Lab
Holtan, H. N.	Res. Hydrology Eng.	Hydrograph Lab
Hooven, N. W., Jr.	Res. Animal Scientist	Animal Operations Unit
Howell, R. K.	Res. Plant Pathologist	Air Pollution Lab
Hyland, H. L.	Botanist	Germplasm Resources Lab
Keyes, J. E., Jr.	Res. Animal Scientist	Genetics & Manag. Lab
Klingman, D. L.	Weed Control	Turfgrass Lab
Kulik, M. M.	Res. Plant Pathologist	Seed Quality Lab.
Lentz, P. L.	Botanist	Mycology Lab
Lindahl, I. L.	Res. Chemist	Ruminant Nutr. Lab
Louloudes, S. J.	Res. Entomologist	Insect Pathology Lab
Lynch, G. P.	Res. Animal Scientist	Ruminant Nutrition Lab
Marsh, P. B.	Res. Plant Physiologist	Nutritional Microbiol. Lab
Moe, P. W.	Supvry Res. Animal Sc.	Ruminant Nutrition Lab
Murray, J. J.	Res. Agronomist	Field Crops Lab
Neal, J. W., Jr.	Res. Entomologist	Field Crops Lab
Oakes, A. J.	Res. Agronomist	Germplasm Resources Lab
Oltjen, R. R.	Supvry Res. Animal Sci.	Ruminant Nutrition Lab
Ostazeski, S. A.	Res. Plant Pathologist	Field Crops Lab
Owens, L. D.	Res. Plant Physiologist	Plant Nutrition Lab
Pearson, R. E.	Res. Genet. Animal	Genetics & Manag. Lab
Powell, J. B.	Supvry Res. Geneticist	Field Crops Lab
Ratcliffe, R. H.	Res. Entomologist	Field Crops Lab
Redfern, R. E.	Res. Entomologist	Biological Eval of Chemicals Lab
Reynolds, P. J.	Res. Animal Scientist	Ruminant Nutrition Lab
Rumsey, T. S.	Res. Animal Scientist	Ruminant Nutrition Lab
Schechter, M. S.	Res. Chemist	Chemical & Biophysical Control Lab
Schroder, R. F.	Res. Entomologist	Beneficial Insect Introduction Lab
Simpson, M. E.	Res. Plant Pathologist	Nutritional Microbiol. Lab

Name	Field of Interest	Department
Beltsville Agric. Res. Center (Cont.) Northeastern Region, Agricultural Res. Serv. U.S. Department of Agriculture Beltsville, Md. 20705		
Slyter, L. L.	Res. Chemist	Nutritional Microbiol. Lab
Smith, L. W.	Res. Animal Scientist	Biological Waste Management Lab
Terrèll, E. E.	Botanist	Plant Taxonomy Lab
Toole, V. K.	Plant Physiologist	Seed Quality Lab
Tyrrell, H. F.	Res. Animal Scientist	Ruminant Nutrition Lab
Vaughn, J. L.	Microbiologist	Insect Pathology Lab
Waldo, D. R.	Res. Animal Scientist	Ruminant Nutrition Lab
Walker, J. M.	Soil Scientist	Biological Waste Management Lab
Yaklich, R. W.	Res. Plant Physiologist	Seed Quality Lab

U.S. Regional Pasture Research Laboratory  
 North Atlantic Area, Northeastern Region  
 Agricultural Research Service  
 U.S. Department of Agriculture  
 University Park, Pa. 16802

Barnes, R. F.	Forage Evaluation
Berg, C. C.	Genetics (Grasses)
Byers, R. A.	Forage Insects
Fissel, G. W.	Chemist
Gross, C. F.	Soil Fertility
Gustine, D. L.	Biochemistry
Hill, R. R., Jr.	Genetics (Alfalfa)
Hite, R. E.	Plant Pathology
Jung, G. A.	Forage Management
Kendall, W. A.	Plant Physiology
Leath, K. T.	Pathology (Legumes)
Sherwood, R. T.	Pathology (Grasses)
Zeiders, K. E.	Plant Pathology



## SECTION I

## BREEDING, GENETICS, AND PLANT INTRODUCTION RESEARCH

Title: Report of Northeast Regional Plant Introduction Station, Geneva, N.Y.; and Regional Project NE-9 -- The Introduction, Testing, Multiplication and Preservation of Potentially Valuable Plants for Crop Improvement and Industrial Use

Leaders: D. D. Dolan and S. W. Braverman, New York (Geneva)

Evaluation and Seed Increase of Alfalfa Introductions.--During the 1974 growing season, evaluation notes were taken on two plantings of alfalfa introductions; one made in 1973 and the other made in 1974. Using a rating system of 1 to 9, alfalfa introductions were rated for uniformity, habit, vigor, size of plant, number of stems, size of stems, number of leaves, size of leaves, earliness of bloom, amount of seed harvested, and susceptibility to diseases and insects.

Field tolerance to Pseudopeziza medicaginis was observed in P.I. 206573 Greece and 209091 Peru. Some tolerance was also noted in P.I. 210440 Iraq and P.I. 223388 Iran. Leafhopper tolerance was observed in P.I. 209091 Peru.

During the preliminary evaluation the following alfalfa introductions appeared promising and worthy of more thorough evaluation by cooperators in the region: P.I. 204885 Turkey, 253444 Yugoslavia, 234817 Switzerland, 196247 India, 268065S Sweden, and G-28869 Canada. (Seeds of each are now available from the Plant Introduction Station.)

One of the above (P.I. 253444) appeared to be an interspecies hybrid M. sativa X M. falcata.

One introduction P.I. 255962S had short, dense plants with short internodes, the plants being only 40 cm tall. The leaves are roundish and dark green.

Two introductions of alfalfa appeared very susceptible to leafspot caused by Pseudopeziza medicaginis: P.I. 235736 and 319712.

Evaluation and Seed Increase of Red Clover Introductions.--Red clover introductions carried over from 1973 that looked promising in their second season of growth, are as follows: P.I. 262570 USSR, 303065 Finland, 303066 Finland, 303080 Finland, 304778 Sweden, 304781 Sweden, 304785 Sweden, 306190 Great Britain, 306193 Great Britain, 306194 Great Britain, 314841-42 Norway, 315534 USSR, 315538 USSR, 368023 Argentina, 376880 New Zealand, and G-21245 Wisconsin.

The following red clover introductions planted in 1974 appeared promising during the first growing season: P.I. 229799 Finland, 235849 Sweden, 236458 Finland, 304294 Finland, 304537 Turkey, 304779 Sweden, and 384056 Poland.

Evaluation and Seed Increase of White Clover Introductions.--The following white clover introductions carried over from the 1973 planting, appeared promising in 1974, their second season of growth: P.I. 214208 Israel, 224680 England, 229655 Australia, 234679 France, 314588 USSR, 345529 Australia, 350706 Australia, 367898 Germany, and 376882 New Zealand.

White clover introductions most free of virus infection are: P.I. 108721, 201214, 234680, 224680, 234679, 319138, 345530, and 350706.

White clover introductions most free of leafhopper damage are the following: P.I. 291214, 232109, 234680, 237291-92, 237735, 230183, 234679, 319137-38, and 350706.

Evaluation and Seed Increase of Forage Grass Introductions.--The 1973 and 1974 plantings of forage grass introductions comprised introductions of tall oatgrass, orchardgrass, and timothy. Introductions of these grasses were rated for uniformity, habit, vigor, culm height, leaf height, plant size, number of culms, size of culms, leafiness, leaf distribution, leaf size, leaf color, earliness of bloom, susceptibility to disease and insects.

In Supplement I to the Annual Report of NE-9, dated January 13, 1975, the Coordinator released a list of the most promising forage grass introductions that should be further evaluated by cooperators in the Northeastern Region. This list contains 25 introductions of tall oatgrass, 4 introductions of orchardgrass, and 10 introductions of timothy. Most of the timothy introductions are of the hay type, but a few procured from the Grass Breeding Station at Aberystwyth, Wales are of the pasture type. Seeds of each of these forage grass introductions are presently being distributed by the Coordinator on request.

Reaction of Lotus spp. to Myrothecium verrucaria.--Several Lotus spp. were inoculated and judged for their reaction to Myrothecium verrucaria in greenhouse experiments. Several L. corniculatus plant introductions and cultivars were moderately to highly susceptible while L. corniculatus var. hirsutus was slightly susceptible. P.I. 311427 L. affin. decumbens from Spain and P.I. 311429 L. creticus, Spain, were rated as resistant. 'Cayuga' alfalfa, and 'Aurora' white clover were moderately susceptible while 'Merit' white clover, 'Pennscott' red clover, and Kura clover (Trifolium ambiguum) were slightly to moderately susceptible.

Title: Project NE-74 - Breeding of Improved Varieties of Forage Species Adapted to the Northeast

Leader: H. M. Schaaf, Chairman, Regional Technical Committee

Contributors: The Connecticut, Maryland, New Hampshire, New York (Cornell), and Pennsylvania Agricultural Experiment Stations; USDA-ARS, U.S. Regional Pasture Research Laboratory; USDA-ARS, Beltsville, Md.; USDA, Cooperative State Research Service; and the American Seed Trade Association

Strain synthesis procedures, seed production and strain evaluation for forage species important to the Northeast were continued in 1974. Work is in progress on seven species at five Northeastern State Experiment Stations; at USDA-ARS, U.S. Regional Pasture Research Laboratory; and at USDA-ARS, Beltsville, Md.

#### I. Studies on strain synthesis:

Alfalfa. The Syn 3 generations of 100 experimental synthetics with 1 to 16 parents, were established in a field nursery in 1974 to determine effects of the parent number on synthetic performance (USRPRL).

Inbred lines for use as parents in synthetics or hybrids have been developed from the varieties, Saranac and Iroquois.  $S_4$  lines will be used to measure effects of parent line inbreeding on forage yield and related traits (NY).

Orchardgrass. Conventional synthetics, restricted polycrosses, single crosses, and double crosses derived from the parental clones of varieties Pennmead and Pennlate did not differ significantly in average forage yield. Results indicate breeders have latitude in choice of procedures to formulate orchardgrass synthetics (Pa).

Timothy. Synthesis effects observed in timothy relate closely to genetic shifts in average date of anthesis. Since maturity and seedling vigor are positively associated, each increase generation allows selection of earliest genotypes. Shift effects have been demonstrated repeatedly for both yield and DM percentage of herbage (which reflects maturity) in comparisons of successive generations of synthesis products (NY).

Hybrid vigor in single cross combinations was most dramatic in seed yield (evaluated in drilled rows). Expressions of hybrid vigor in forage yield (evaluated in solid stands) are difficult to separate from effects of shifts in maturity. Yield reduction from loss of heterozygosity is counterbalanced by yield increase from the shift toward early maturity in advanced generations. There are indications that fertility relationships among parents can be important to performance when parent number is small. A series of cage-isolations was established in 1974 to produce combinations using 3- and 4-clone synthetics as parents in order to check on relative performance and stability in narrow- and wide-based synthetics (NY).



## II. Genetic studies:

Alfalfa. Parental genotypes had significant effects on inbreeding depression; average vigor decreased but exceptions existed. Level of parental inbreeding had no consistent effect on GCA or SCA. The results indicate relatively vigorous types can occur in inbred populations (USRPRL).

Crownvetch. Varied levels of  $\beta$ -nitropropionic acid (BNPA), an antiquality constituent, were found, and selections were made for high and low levels. A field study indicates clonal differences in IVDMD that are relatively stable from year to year and in widely different environments. Diallel crosses were established in the field to determine the inheritance of BNPA content and IVDMD (Pa).

Orchardgrass. Four populations of orchardgrass are undergoing phenotypic recurrent selection for animal preference as well as yield and quality of forage. Clones are being selected for a combination of vigor, height, IVDMD, and protein content. In nurseries of spaced plants, upright clones were grazed by sheep in preference to decumbent clones (Pa).

Twenty-eight orchardgrass varieties were tested in a controlled environment for reaction to artificial inoculation with purple leafspot fungus. None were highly resistant to the organism on average but varied greatly for numbers of individual resistant plants. Plants with most resistance were intercrossed and progenies are currently being scored (USRPRL).

Smooth bromegrass. Significant differences for stomate length and frequency were found among 7 brome grass varieties; neither trait was significantly correlated with forage yield. A half diallel involving 5 parental clones indicated highly significant GCA effects for stomate length and frequency, leaf length, leaf width, leaf area, dry weight per tiller and per plant. SCA effects were not significant. Narrow-sense heritabilities for the above traits were: 0.53, 0.74, 0.48, 0.59, 0.55, 0.39 and 0.14, respectively (NH).

Octoploid plants had significantly more total stomatal aperture per unit area than hexaploids or tetraploids, but 7 octoploids did not differ significantly. Similar diurnal behavior of stomata was observed among octoploid varieties; stomata on tetraploid plants apparently close earlier in the day. Total stomatal aperture was significantly correlated with stomatal width. Stomatal length on the cotyledonary leaf proved to be a reliable index for isolating polyhaploid plants (NH).

Genetic work is underway with a rolled leaf mutant in brome grass (NH).

## III. Seed production:

Alfalfa. Certified seed of two new varieties, Saranac AR and Honeoye, was produced for the first time in 1974. Saranac AR is highly resistant to anthracnose, an important disease in the southeastern part of the Northeast region. Adding anthracnose resistance insures that Saranac can continue to be used throughout the region. Certified Saranac AR will be

distributed for planting in 1975. Honeoye is intermediate in type between Iroquois and Saranac and superior to Saranac in forage yield and persistence. It should be best adapted in New York and the New England States. Certified Honeoye will not be available for general use until 1976 (NY).

ARC, the anthracnose resistant variety derived from Team, was released in 1974. It is also highly resistant to the pea aphid and moderately resistant to bacterial wilt. ARC should be adapted to most of the Middle Atlantic States, the Southeast, and southern parts of the Midwest. Increases for production of Foundation and Certified Seed have been established (ARS, Beltsville). Foundation seed of the new Champlain variety was produced in the Northwest in 1974. This was used to establish a large acreage in the Northwest for Certified seed production in 1975 (NY).

#### IV. Evaluation of new synthetics:

From 1969 through 1974, annual trial series for public and private alfalfa varieties have been established in CT, MD, NH, NY, and PA. In 1974, 15 of these trials were harvested for yield and 5 new tests were seeded. Summaries of the data are available on 34 trials.

#### USEFULNESS OF FINDINGS:

As has been noted in previous annual reports, improved hay and pasture varieties developed under NE-74 and its predecessor, NE-28, have found wide use in the Northeast and elsewhere. Compared to older varieties, these alfalfa, timothy, brome grass, and orchardgrass varieties developed through cooperative efforts contribute additional hay and pasture forage worth at least 33 million dollars annually. New varieties now under increase will give further increased yield potential for high quality forage. The region's large dairy industry and other livestock enterprises are in trouble and this added production potential has appreciable significance to their survival. Millions of acres of idle farmland within the region are well suited for the production of perennial forages, they represent a reservoir of future food production capacity.



Title: Project NE-75 - Breeding for Improved Forage Quality

Leader: C. C. Lowe, Chairman, Regional Technical Committee

Contributors: The Minnesota, New York (Cornell), Pennsylvania, South Dakota, and Wisconsin Agricultural Experiment Stations; USDA-ARS, U.S. Regional Pasture Research Laboratory; and USDA, Cooperative State Research Service

I. Variability in plant constituents and application of quality assay techniques:

A diallel cross study for nine alfalfa clones varying in leaf/stem ratio and leaflet number (NY) gave consistent values for IVDMD and crude protein over three growth periods. GCA was highly significant and SCA negligible in this population for these quality traits. Little correlation was found for IVDMD values of 32 smooth brome grass genotypes in different harvests or in evaluation as spaced plants and vegetative plots (SD). IVDMD values appeared related to time and amount of panicle formation. Twenty-four clones each from the crownvetch cultivars, Penngift and Chemung, were compared for IVDMD, protein and morphological traits (Pa). IVDMD was not significantly correlated with flowering, stem length or regrowth height; it was correlated with DM percentage and protein but not enough for prediction. Comparisons of perennial grass species have shown wide differences in nonstructural carbohydrate content (4-40% of DM) (USRPRL). Cultivar and seasonal effects are evident within species. Mineral analyses of regrowth in reed canarygrass showed significant GCA for plant uptake of P, K, Ca, Mg, Cu and Zn (Minn). Meadow voles were used to evaluate leaf palatability of tall fescue, reed canarygrass and ryegrass-fescue hybrids (USRPRL). Perline level in Festuca genotypes did not influence palatability, but palatability was found negatively correlated with total alkaloid content in 14 reed canarygrass clones. Grazing trials with lambs were used with eight clones of reed canarygrass differing in alkaloid type and concentration (Minn). Low-alkaloid clones averaged 82 g/day animal gain while high-alkaloid clones produced 58 g/day gain in early summer and -76 g/day loss in late season.

II. Source population development and variety synthesis and evaluation:

Acid-pepsin DMD analysis is being used for quality selection in a source population for smooth brome grass (Wis). Twenty-four "low-alkaloid" reed canarygrass genotypes were isolated from a source population of 2,400 using a chemical precipitation technique (Minn). Agronomically diverse clones with an alkaloid concentration of less than 0.1% will be intercrossed for selection. A source population of 1,000 crownvetch plants was selected for high and low levels of  $\beta$ -nitropropionic acid. Vegetative tissue levels ranged from 0.20 to 3.68% compared to source cultivar values of 1.38, 1.27 and 1.05%. Selections will be used in breeding (Pa). High and low selection for Mg accumulation in alfalfa (USRPRL) produced clones that were used to produce 2-clone synthetics. Four high-Mg and four low-Mg synthetics will be evaluated. Nine 4-clone (Lolium x Festuca) synthetics

from parents found variable in palatability to dairy cows were evaluated for yield and IVDMD (USRPRL). Significant IVDMD differences were found and production distribution was different from cultivars of tall fescue. In vivo and in vitro tests on 2-clone synthetics from high and low IVDMD selected parents in smooth bromegrass have not given a digestibility difference (SD). Six alfalfa synthetics with varying multifoliolate leaf expression have differed in leaf content, IVDMD and protein but have been lower in forage production than trifoliolate cultivars (NY). Orchardgrass synthetics from parents selected high and low for IVDMD and protein have been produced for yield and quality evaluation (Pa).

#### USEFULNESS OF FINDINGS:

Work to date has provided a realistic base of information for allocation of research effort for quality improvement in the major forage species. Selection has been generally effective in forages containing anti-quality constituents whereas improvement in those forages inherently high in quality requires large effort for small gain. Approximative quality techniques are accurate but generally too expensive for large population screening; other methods are necessary for preliminary selection. Results suggest attention should be directed to mutant forms in basic plant structures to effect significant quality change.

Title: Breeding Alfalfa for Tolerance to Aluminum Toxicity in Acid Soils

Leaders: J. H. Elgin, Jr., J. E. McMurtrey III, and C. D. Foy, USDA, ARS, Beltsville, Md.

Aluminum toxicity is believed to be a factor restricting root growth in the acid subsoils of the eastern U.S. Alfalfa is a deep-rooting plant capable of utilizing both moisture and minerals in the lower soils, resulting in marked production during periods of drought. Where toxic levels of aluminum occur, deep rooting is prevented and alfalfa production is disappointing. Using nutrient solution culture techniques, we are developing aluminum tolerant alfalfa strains for use on the acid subsoils of the eastern U.S. Screening is presently in initial stages and no results are available.

Title: Breeding Alfalfa for Disease and Insect Resistance

Leaders: J. H. Elgin, Jr., R. H. Ratcliffe, J. H. Graham, T. E. Devine, and T. A. Campbell, USDA, ARS, Beltsville, Md.

Evaluation studies of Arc alfalfa were continued. Arc, the first cultivar with high resistance to anthracnose, a highly destructive fungus disease, was developed cooperatively with the North Carolina, Maryland, Virginia, and Pennsylvania Agricultural Experiment Stations and released in October 1974. In laboratory and field trials Arc has continued to demonstrate performance superior or equal to existing cultivars. It is expected to be widely planted in the Middle Atlantic, Southeastern, and South Central States.

The inheritance of anthracnose resistance was studied and determined to be conditioned by a completely dominant gene inherited in a tetrasomic manner. In further anthracnose studies, 140 alfalfa cultivars and strains were evaluated for anthracnose resistance. Five cultivars (Arc, Team, Gemini, Luna, and 183) and several experimental strains developed in our laboratory (among which was the progenitor of Saranac AR) were found to be significantly more resistant than the susceptible checks Cherokee, Saranac, and Williamsburg.

New studies to develop alfalfa strains resistant to *Mycoleptodiscus* crown and root rot and *Fusarium* wilt were initiated. When resistant strains are developed field studies will be conducted to determine the importance of these two root diseases to alfalfa production.

A survey of 419 annual Medicago species in our collection was initiated for resistance to alfalfa weevil larval feeding. Interspecific hybridization with M. sativa will be attempted with the most promising species.



Title: Breeding for Quality and Disease Resistance in Alfalfa

Leader: R. R. Hill, Jr., Pasture Research Laboratory

Statistical analyses of genetic variability for mineral concentration in alfalfa single crosses have been completed, but those for in vitro digestibility, lignin, acid detergent fiber, and protein are still underway. The alfalfa forage from our experiment contained less P, Cu, Zn, and Na, more K and Ca, and a higher Ca/P ratio than recommended for moderately producing dairy cattle. Estimated ranges in mineral concentration that could be achieved through plant breeding indicated that (1) P concentration could be increased to a level that meets dairy cattle requirements; (2) correction of the Zn deficiency and the excessive Ca/P ratio for dairy cattle diets by breeding alfalfa appeared feasible, but would be more difficult than correction of the P deficiency; (3) alfalfa breeding alone apparently could not correct deviations from dairy cow requirements for Cu, Na, K, and Ca concentrations. Estimates of genotypic correlations for mineral concentrations indicated that adverse correlated responses to selection for concentrations of most elements would not be serious.

The third cycle of mass, half-sib family, full-sib family, and alternating generations of self-family and half-sib family selection for resistance to Phoma and Leptosphaerulina leafspots was completed. Contrary to expectations at the beginning of the experiment, response to selection for resistance to Leptosphaerulina appears to be greater than for Phoma.

Title: Breeding and Cytogenetics of Alfalfa and Red Clover

Leaders: R. W. Cleveland, M. L. Risius, and J. S. Shenk, Pennsylvania

A phenotypic recurrent selection (PRS) program was continued for the improvement of creeping rooted (CR) alfalfas in yield and other production traits. Plants were selected to produce progenies. Expanded evaluations of CR and other alfalfas for adaptation in southeastern Pennsylvania (SE PA) and for persistence under disease stress are planned. Nurseries in SE PA have been maintained and evaluated for several years with the intent to select superior persistent parental stocks. Results of yield trials in SE PA have continued to show that Arc and Saranac AR alfalfa cultivars are superior in persistence and production, and that this is apparently attributable to anthracnose disease resistance. The existence of several other important alfalfa diseases and insects, to which many varieties seem to be susceptible in SE PA suggests that the complete solution to the problem of persistence may not be embodied in any single variety we have had under test.



A PRS program was continued for the improvement of red clover (RC) in northern anthracnose and mildew resistance. Intercross populations of RC were established for disease evaluations in the field. Work was expanded to include plant introductions crossed with adapted RC strains with the intent to create interbreeding populations from which unusual genotypes may be selected. Nurseries were established for this purpose. Also, a mixed-ploidy RC population was established in 1974 to enable the selection of 4x plants and the eventual production of a tetraploid strain.

Title: Breeding Crownvetch for Forage and Slope Stabilization Usage

Leaders: M. L. Risius, J. S. Shenk, and R. W. Cleveland, Pennsylvania

Note: Some of this research was done cooperatively between Agronomy Department and U.S. Regional Pasture Research Laboratory

Variation for quality and morphological traits among individual plants of the crownvetch cultivars Penngift and Chemung, was characterized to ascertain the potential for improving the quality of crownvetch forage by selection and breeding. Within each cultivar, forage was harvested at first flower from 24 plants. Significant variation for morphological traits, IVDMD, and protein was found among plants within each cultivar. Differences among plants for cell wall concentration and composition were significant for Penngift only. Flowering date, stem length, and regrowth height were not significantly correlated with IVDMD, none of the relationships were strong enough to use for predictive purposes.

The compound,  $\beta$ -nitropropionic acid (BNPA), has been reported to be an anti-quality constituent in crownvetch forage. Variation for BNPA levels among crownvetch plants was investigated in cooperation with D. L. Gustine of the U.S. Regional Pasture Research Laboratory, University Park, Pa. In a preliminary evaluation, about 1000 plants from three crownvetch cultivars, Penngift, Chemung and Emerald were grown in the greenhouse. Levels of BNPA in vegetative tissue ranged from 0.20 to 3.68%. The cultivars, Chemung, Emerald and Penngift averaged 1.38, 1.27 and 1.05% BNPA, respectively. Two related species, Coronilla scorpioides and Coronilla globosa did not have BNPA in vegetative tissue. Selection of plants for high and low levels of BNPA were made and will be utilized in the selection and breeding program.

Title: Breeding and Genetics of Bromus inermis

Leaders: G. M. Dunn, H. Z. Lea, and G. Y. Tan, New Hampshire

The variety Saratoga and Wisconsin synthetics B-6 and B-7 were highest in yield among 10 entries seeded in 1973. Significant differences were found for stomatal length and frequency among seven brome grass varieties, but neither trait was significantly correlated with yield. A half-diallel cross indicated highly significant GCA effects for stomatal length and frequency, leaf length, width and area. SCA effects were not significant. Narrow sense heritabilities for above traits were 0.53, 0.74, 0.48, 0.59 and 0.55, respectively. Stomatal length on the cotyledonary leaf is a reliable index for screening for polyploid plants. Octoploids had significantly more total stomatal aperture (estimated with a porometer) than hexaploids or tetraploids in the field, but seven octoploid varieties did not differ significantly. Similar diurnal movements of stomata were observed among octoploid varieties, but stomata apparently closed earlier on tetraploid plants. Total stomatal aperture was significantly correlated with stomatal width as measured under a microscope.

Title: Forage Yields and In Vitro Dry Matter Disappearance of Synthetics Derived from Lolium X Festuca Hybrids

Leaders: Clyde C. Berg and R. F. Barnes, Pasture Research Laboratory

Clones of Lolium-Festuca hybrid origin were used to form nine 4-clone synthetics. These clones were selected on the basis of either good polycross progeny performance or high and low palatability ratings with dairy cows. The Syn-2 generations of the nine synthetics plus five tall fescue cultivars were evaluated in broadcast plots from 1970 to 1972. The check cultivars usually produced larger dry matter yields than the synthetics at the first harvest (June), but forage yields of some synthetics were equal to or larger than the check cultivars in mid-summer and fall harvests. Highly significant harvest by synthetics interactions were observed within and among years. Differences in in vitro dry matter disappearance (IVDMD) were highly significant at each harvest. Estimated yields of digestible dry matter (dry matter yield X IVDMD) were similar to dry matter production because of the large range in dry matter production and relatively small range in IVDMD. However, two synthetics were equal to the check cultivars in estimated production of digestible dry matter in nearly all harvests.

Title: Application of Mutation Breeding Procedures for Improvement of Forage Plants

Leaders: J. B. Powell and J. J. Murray, Beltsville, Md.

Inducing mutations in crop plants is one method of increasing variability for further improvement of germplasm. The techniques which were successful with bermudagrasses in producing more than 300 new lines have now been applied to Kentucky bluegrass. The mutation breeding approach is a means of circumventing the difficulty in this species of securing hybrids and recombinants because of its apomictic breeding behavior. We treated rhizomes of Belturf with gamma rays and obtained numerous mutations showing dwarfs, early types, yellow-green types, stiff-erect types, fine leaf types, as well as changes in disease susceptibility. Tests are continuing to determine if seed harvested from these mutant types retain the characteristics of the mother plant.

Title: Breeding for Improved Varieties of Forage Species Adapted to the Northeast

Leaders: C. C. Lowe, R. P. Murphy, and H. M. Schaaf, New York (Cornell)

Development of inbred alfalfa lines for use in synthetic population studies was continued. Selections were made in  $S_3$  progenies of Iroquois for  $S_4$  production.  $S_4$  lines of the Saranac variety were produced the previous season.

Synthesis procedure comparisons with timothy are also continuing. Forage and seed yield data were collected on trials containing the following types of synthetic progenies for 2-clone combinations:  $(S_0 \times S_0)$ ,  $(S_{1F1} \times S_{1F1})$ ,  $(S_{1F2} \times S_{1F2})$ ,  $(S_{1F1} \times S_{1F1})_2$ ,  $(S_{1F1} \times S_{1F1})_3$ ,  $(S_{1F2} \times S_{1F2})_2$  and the conventional Syn 2 generations. Results to date have indicated differences between synthesis procedures and these are in part due to genetic shifts toward earlier maturity with each generation of seed increase. The evidence suggests importance for expression of hybrid vigor in seed yields but not in forage. New synthetic combinations are being evaluated.



Title: Breeding for Improved Varieties of Forage Species Adapted to the Northeast

Leaders: J. S. Shenk, R. W. Cleveland, and M. L. Risius, Pennsylvania

A 3-year study of the synthesis products among the four parental clones of Pennlate (PL) and Pennmead (PM) was completed. The objective was to determine the yield responses of different methods of synthesizing progeny from the four parental clones of PL and PM. The synthesis products tested were conventional synthetics (CS), restricted polycrosses (RP), two types of single crosses (SC), and three types of double crosses (DC). The RP of clone XLI-8 and MIII-8 significantly outyielded the CS of PL and PM, respectively. Progeny of each of these clones were highest in yield in both types of their respective single crosses. As the level of inbreeding among SC increased, yields decreased, but no consistent yield trend existed among DC derived from these single crosses. The only way to produce higher yielding varieties from these clones would be to reduce the number of generations between breeder seed and variety release.

Estimates of genetic variance components in Coronilla varia L. vs. Chemung were made assuming autotetraploid inheritance. Fifty randomly selected plants were mated in a nested design. The parents and progenies were evaluated in two growing seasons for forage yield at each of two harvests per season, total forage yield, and plant height at each harvest. Estimates for total genetic variance were significant for all characters except first harvest forage yield. Quadrigenic variance was the most important component for most characters studied while, estimates of additive genetic variance were positive but of minor importance. Heritability estimates were low for each of the characters.

Title: Breeding for Improved Forage Quality

Leaders: J. S. Shenk, R. W. Cleveland, and R. L. Cowan, Pennsylvania

Clone height and neutral detergent fiber (NDF) were the best indicators of forage quality among orchardgrass clones. Only those clones with high phenotypic buffering capacity for height, protein, and NDF were stable in their quality characteristics over years and harvest. Seed was produced from clones selected for high or low in vitro dry matter disappearance (IVDMD) and protein (P). These synthetics will be evaluated in field trials next year.

The weanling meadow vole has shown potential as a bioassay of both cereal grain and forage quality. Studies were conducted to relate weanling vole responses to those of other animal species. The vole has an apparent lysine requirement similar to that of the rat. Voles and rats



responded in a similar manner when fed four maize genotypes--normal, sugar-2, opaque-2, and opaque-2 sugary-2. A second study was conducted with six alfalfa forages to compare the intake and daily weight gain of weanlings to intake and milk production of dairy cows. A linear equation was calculated that explained 91% of the variation in cow milk production from vole weight gain. Feeding trials were conducted to determine whether feeding diseased forage to animals is potentially dangerous. Alfalfa forage was infected with one of five foliar pathogens and the feeding value of the diseased forage was compared to healthy forage. Voles detected differences between diseased and healthy forage that were not detected by chemical analysis or IVDMD.

Title: Breeding of Perennial Forage Grasses

Leaders: J. S. Shenk, R. W. Cleveland, and M. L. Risius, Pennsylvania

The phenotypic recurrent selection program was continued with four populations (A, B, C, D) to improve the production of quality orchard-grass forage. First generation seed was obtained from clones in population A and B that were selected for above average performance in vigor, height, in vitro dry matter disappearance (IVDMD) and protein (P). Clones were selected after 2 years' data from population C. Population D will be screened for the first time next year. The sheep preference studies of individual clones were continued. Upright clones were preferred over decumbent clones. A correlation of 0.60 was obtained between July and September grazing trials.

A mathematical model was developed to simulate dairy cow milk production of forage from a field plot trial containing 10 experimental synthetics and Pennmead. Model predictions were expressed as net dollars/hectare return to the dairy farmer relative to the standard variety Pennmead. Synthetic 4 was significantly higher in yield than Pennmead but only \$15/ha better than Pennmead even though it was significantly lower in IVDMD and P. Synthetic 6 was significantly higher in IVDMD than Pennmead but its low yield resulted in a significantly lower dollars/hectare value of -\$95. Only synthetic 9 was equal in quality, higher in yield, and highest in dollars/hectare compared to Pennmead; however, neither yield nor the dollars/hectare value was significantly better than Pennmead.

Title: Breeding and Cytogenetic Investigations and Improvement of Cool Season Perennial Forage Species

Leaders: R. P. Murphy and C. C. Lowe, New York (Cornell)

A comprehensive study was begun on alfalfa yield and forage quality under different managements and growing environments. Nine cultivars including recently released New York varieties are being evaluated under three systems of management intensity at each of three locations. The sites reflect the range in soil resources for alfalfa production that occur in New York State. Forage yield, in vitro digestibility, crude protein and leaf percentage are being determined for all production fractions over the total season. The purpose is to identify optimum combinations for maximum production of usable feed per acre and to indicate direction for further selection for raising the ceiling on production of usable feed constituents from alfalfa.

First season results reflected known performance differences among the varieties for dry matter yield. There was little var. x mgt. or var. x location interaction. Differences among the three intensive management systems for total season dry matter were small--yield ceilings were apparently set by the available moisture. Quality data are not entirely summarized to date but an overall conclusion that appears certain is that the differences in forage quality among present varieties have no practical significance over a wide range of recommended management practices. Forage age at harvest, time of season and specific environments produced marked differences in protein content, digestibility and leaf content but variety traits like growth type, stem size and leaflet number did not result in any significant difference in quality that give any overall quality advantage on a total-season basis. Evaluation will be continued but current information suggests future quality improvement is most likely from types better able to withstand the pressure of early and possibly more frequent harvest. Morphological traits associated with quality cannot be ignored because it is apparent that selection can reduce quality but selection specific to improve leafiness, stem size, etc., to produce higher average quality does not appear effective for alfalfa under fairly intensive cutting management.

Selection is being continued for possible tolerance to the alfalfa blotch leaf miner and a field nursery has been established in an area of snout beetle infestation in New York to indicate possible tolerances to this insect. A New York experimental synthetic derived from clones selected for field tolerance to alfalfa weevil has shown less evidence of weevil feeding on first growth forage in comparative trials with Team, Weevilchek and several proprietary strains that have been developed for alfalfa weevil tolerance.

Title: Morphological and Anatomical Traits in Plants Influencing Digestibility

Leaders: J. B. Powell, D. Dinius, N. J. Chatterton, and R. L. Steere, Beltsville, Md.

Progress continues on the development of techniques to screen large numbers of grass genotypes for cuticular traits affecting digestion. Barley was selected as the test organism because of the availability of large numbers of cuticular mutants in this species. The cuticular and surface waxes have a major effect on the digestion of unbroken and undamaged leaves. Some plant leaves are not penetrated by rumen microbes after 30 hours of exposure. Our goal is to perfect techniques of evaluating precisely the cuticle characteristics of plants whereby many thousands of samples could be screened in a short period of time.

Transections of forage plant leaf and stem tissues reveal anatomical differences. Cell structure and cell arrangement in the tissue determine the microbial attack. The present investigations have as their goal the detection and understanding of cellular traits of plants which influence the digestion process by microbes, with a view of combining desirable traits into improved breeding lines. Special techniques using scanning and transmission electron microscopy have been employed to resolve the differential microbial attack of plant cells.

Title: Correct Scientific Names for Crop Species

Leader: E. E. Terrell, Beltsville, Md.

We are compiling checklists of correct scientific names for economically important species of vascular plants. At present, two lists are in progress--one on economic plants in general and one on introduced agricultural grasses. These lists will also include well-established common names. A list of scientific names for 1000 world crop species (including some forage species) was included in a paper by Duke and Terrell (1974). The correct scientific names for almond, buckwheat, coca, lentil, okra, pecan, southern pea (cowpea), sweet cherry, and watermelon were discussed by Terrell and Winters (1974).



## SECTION II

## ENTOMOLOGY RESEARCH

Title: Recovery and Identification of the European Alfalfa Beetle from Eastern United States

Leader: R. D. Gordon, Systematic Entomology Laboratory, IIBIII, Washington, D.C.

The European alfalfa beetle, Subcoccinella vigintiquatuorpunctata (L.), a lady beetle related to the Mexican bean beetle and accidentally introduced into Pennsylvania and New Jersey, was first identified in this country by Dr. Gordon in 1974. This beetle is a serious pest of alfalfa in eastern Europe and western Asia and has been observed there feeding on carnations and sugar beets as well. In this country, it has been detected only on bouncing-bet, Saponaria officinalis L., but it is being carefully watched by field workers for any tendency to move to alfalfa. All collections of suspected European alfalfa beetle are sent to the Systematic Entomology Laboratory for confirmation.

Title: Effect of the Alfalfa Blotch Leaf Miner on Yield and Quality of Alfalfa Hay

Leader: G. B. MacCollom, Vermont

Field plots were established in 1973 on alfalfa. Infestations of the blotch leaf miner, Agromyza frontella (Rondani) in two locations resulted in 35% to 40% of leaflets mined. Four insecticidal treatments gave from 60% to 98% control of mines, but no differences could be shown in yield or hay quality. Infestations did not appear in 1974 for continuation of the studies, but leaf miner populations have appeared in 1975, and similar studies are being continued.



Title: Effect of the Alfalfa Weevil on Alfalfa Yield, Quality, and Morphology

Leaders: Gary W. Fick, Beverly Wen-Yuh Liu, and George A. Maybee, New York (Cornell)

The discovery that the commonly used alfalfa weevil insecticide, Alfatox, can retard alfalfa growth without producing obvious phytotoxic symptoms prompted us to take a closer look at the effects of the insecticides we have been using on alfalfa growth. In 1973, the first year of screening for phytotoxic and growth enhancing effects, unsprayed control yields were not significantly different than insecticide sprayed treatments under field conditions with low populations of alfalfa insect pests. The insecticides used were methoxychlor plus malathion ( $1.7 \text{ kg ha}^{-1}$  applied 1, 2, or 3 times), heptachlor ( $1.1$  to  $4.5 \text{ kg ha}^{-1}$  applied once), and carbofuran ( $0.3$  to  $1.1 \text{ kg ha}^{-1}$  applied once). The overall mean yield was  $12.7 \text{ tons ha}^{-1}$ . The field experiment was repeated in 1974, and greenhouse studies to develop screening techniques for nonvisual effects of insecticides on alfalfa growth are in progress.

Our early studies on the effect of alfalfa weevil defoliation on herbage quality indicated that leaf percentage was not a good indicator of the extent of weevil injury. Because the weevil feeds mainly on blades and our leaf fractions included morphological parts other than blades, we initiated trials to evaluate our separation techniques. Three-way separations of undamaged alfalfa herbage into blades, stems minus 3 cm of tip, and other parts (stem tips, petioles, stipules, and reproductive parts) over 2 years showed that other parts represent a nearly constant 11% of the total herbage after the bud stage is reached. For every 100 g of herbage, the other parts contributed about 9 g of in vitro digestible dry matter and 2 g of crude protein. The relative constancy of the other parts fraction indicates that including them with blades in two-way separations will not produce a variable underestimation of the effect of defoliation on leaf percentage. It now appears that weevil defoliation has less than anticipated effects on leaf percentage and forage quality because it retards stem growth as well as removes blades. Detailed morphological and quality measurements are now being made on weevil damaged material.

A computer model of alfalfa growth (ALSIM 1) is being developed. It produces estimates of the yield components of the alfalfa crop that are updated at simulated daily intervals. Weather data are required input and various cutting management programs can be simulated. The estimated maximum alfalfa yield with average weather at Aurora, N.Y. was  $16.1 \text{ tons ha}^{-1}$ . Subprograms to compute forage quality are planned.

Title        Separating Alfalfa Weevil Larvae from Alfalfa Foliage Samples

Leader:    R. F. W. Schroder, Beltsville, Md.

A method was developed by which first-fourth instar alfalfa weevil larvae were dislodged from alfalfa in a high speed blender and then separated from the debris by washing through a series of sieves. An average of 93.7% of all the first-fourth instar larvae were extracted by this method. This extraction method can serve as a valid technique for estimating the first-fourth instar larvae populations in 1 ft<sup>2</sup> of alfalfa. Modifications of this procedure may be useful in other insect population studies.

Title:        Cross-Mating Studies Among Strains of the Alfalfa Weevil from the United States and Western Europe

Leader:    R. F. W. Schroder, Beltsville, Md.

Cross-mating among strains of the alfalfa weevil from Maryland, Utah, France and Germany demonstrated that partial intersterility existed between Maryland weevils and the other three strains. The Maryland alfalfa weevil probably originated from other areas in the Old World. The complete compatibility demonstrated between the Utah and the western European strains indicates that the western U.S. alfalfa weevil originated in western Europe.

Title:        Improved Growth and Establishment of Spring Seeded Alfalfa from Carbofuran and Phorate Granules for Potato Leafhopper Control

Leader:    R. A. Byers, Pasture Research Laboratory

Application of systemic insecticide granules during spring seeding of alfalfa is a method to control potato leafhopper, Empoasca fabae (Harris), that would eliminate spraying new seedlings. Carbofuran and phorate 10% granules, applied immediately after planting alfalfa in Beltsville, Md. and Rock Springs, Pa., increased plant height an average of 1-9.4 cm, had 3-6 more plants per 30.5 cm of row, and up to 1.7% higher protein, but did not increase dry matter yields above that of untreated alfalfa. Carbofuran treated alfalfa had 4.9 potato leafhoppers per sweep in 1973 at first harvest compared to 19.8 per sweep for untreated alfalfa at Rock Springs, Pa. Carbofuran treated alfalfa also had significantly fewer potato leafhoppers per sweep at both Rock Springs and Beltsville in 1974. Phorate and ethoprop were not as

effective in controlling the potato leafhopper. Ethoprop 10% granules at 22.4 and 5.6 kg ai/ha reduced mean plant height up to 9.1 cm, had up to 4 fewer plants per 30.5 cm of row, but in 1 field had 2% higher protein than untreated alfalfa.

All insecticides reduced levels of plant parasitic nematodes in 1974 at Rock Springs. Plant parasitic nematodes were suspected to be important pests of seedling alfalfa.

Carbofuran treated plots had an average of up to 60 dead earthworms per plot while phorate had only an average of 13.2 and untreated alfalfa less than 1. Dead earthworms were observed following the first rain after application of insecticides.

Alfalfa residues, at first harvest at Beltsville in 1973, declined from 0.15 mg/kg to less than detectable at second harvest. Only residues of 3-hydroxycarbofuran were found in alfalfa. Only residues of carbofuran were found in the soil, which declined from 0.26 mg/kg at 11 weeks post-treatment, to 0.03 mg/kg at 20 weeks post-treatment.

Four samples each of alfalfa and soil, collected at first harvest at Rock Springs, had no detectable amounts of residues in 1973.

Alfalfa samples collected at Beltsville and Rock Springs in 1974 at first harvest contained 0.73 and 0.54 mg/kg of 3-hydroxycarbofuran, respectively. Soil samples from Beltsville contained residues of carbofuran which declined from  $1.06 \pm 0.88$  mg/kg to less than 0.01 at 27 weeks post-treatment.

Title: Cooperative Pennsylvania Potato Leafhopper Survey on Alfalfa

Leader: R. A. Byers, Pasture Research Laboratory

A special survey for the potato leafhopper on alfalfa has been organized by a committee consisting of E. Eckess, Animal and Plant Health Inspection Service (APHIS), USDA; Finley Negley, Bureau of Plant Industry, Pennsylvania Department of Agriculture; A. A. Hower, Jr., Department of Entomology, Penn State University; and R. A. Byers, ARS, U.S. Regional Pasture Research Laboratory.

The objective of the survey is to correlate potato leafhopper population densities with forage quality. The survey will begin in late June 1975 on the regrowth of alfalfa following first harvest. Potato leafhoppers will be collected from 26 different fields from sprayed and unsprayed portions in each field. Personnel from APHIS were instructed by the committee to make the sweeps, count and record the insects, and send forage samples to the Pasture Lab for quality determinations.

The committee hopes to establish an economic injury level (number of potato leafhoppers per sweep that reduces quality) for the state of



Pennsylvania. The current economic injury level of one potato leafhopper/sweep was determined in 1942 by USDA. No attempt has been made since then to determine this injury level on modern day forage varieties. Once the actual economic injury level is determined, it will form a base line for recommending the need for insecticide treatment to individual growers.

Title: Nematicidal Effects of Soil Pesticides When Applied to Alfalfa

Leaders: E. R. Jones, R. H. Swain, K. W. Bell, and R. B. Carroll,  
Delaware

Nematicidal effects of carbofuran and Mocap were evaluated on Saranac during the 1974 growing season. Each material was evaluated on a 1-year-old stand, 3-year-old stand, and on an April 1974 seeding. Furadan 10G (2 lb ai/acre) and Mocap 10G (3 lb ai/acre) were broadcast on 5 x 20 ft plots with a Gandy spreader April 17. The materials were incorporated 2-3 inches in the new seeding and irrigated in using 1 inch of water on the 1- and 3-year-old stands. A complete randomized block design with four replications was used on each alfalfa stand. Nematode samples were taken April (pre-treatment), May 15, and September 27. Parasitic nematodes were determined from samples made up of 10 6-inch cores taken at random from each plot. Data were not normally distributed, therefore, a logarithmic transformation was made before an analysis of variance was conducted on each experiment over three sampling dates. Analysis of variance was made on the population of pin, lesion, and total parasitic nematodes.

Differences in lesion, pin, and total parasitic nematodes between treatments were not significant. Coefficients of variability ranged from 7% to 27% over three dates and three experiments. Nematode populations were significantly different over time in the spring seeding and 3-year-old stand while the populations in the 1-year-old stand remained relatively constant. No trends could be determined from the data analyzed over the three sampling dates. Alfalfa dry matter yields were not significantly affected by any treatment on any age stand.

Title: Reduction of Cereal Leaf Beetle and Frit Fly Infesting Reed Canarygrass by Irrigation with Municipal Sewage Effluent

Leader: R. A. Byers, Pasture Research Laboratory

Twelve clones of reed canarygrass, Phalaris arundinacea L., that were spray irrigated with municipal sewage effluent had a mean of 0.03 larva/clone of cereal leaf beetle, Oulema melanopus L., while the same 12 un-irrigated clones had a mean of 3.2 larvae/clone on June 7, 1974. There-



fore, the sewage effluent achieved almost complete control of the cereal leaf beetle larvae.

The reed canarygrass clones that were irrigated with sewage effluent also had 52.8% fewer culms killed by the frit fly, Oscinella frit L., than unirrigated clones on June 7, and 35.7% fewer dead culms on August 12, 1974. The reduction in dead culms because of irrigation ranged from 0.8% to 79.1% depending upon the particular clone and the date. Clone 19-7 had the lowest mean percentage of dead culms for both irrigated and unirrigated areas on June 7 and for the unirrigated area on August 12. Clone 19-7 is an accumulator of tryptamine alkaloids and indicates that alkaloid concentration may influence resistance to frit fly in certain reed canarygrass clones.

Title: Sporulation Studies of the Japanese Beetle Pathogen, Bacillus popilliae

Leader: R. M. Faust, Beltsville, Md.

Fermentation and biochemical studies of nutrition of Bacillus popilliae indicate that this pathogen has a biochemical lesion that prevents sporulation in artificial media. A modified DNA extraction procedure was developed that yields pure and high molecular weight DNA from other bacterial species necessary for genetic reconstruction of the Bacillus popilliae genome. Isolation and purification procedures for DNA endonuclease (cleavage) and ligase (repair) are in progress. Steady state fermentation for reconstructed less fastidious B. popilliae is being developed.

Title: Control and Bionomical Studies of Livestock and Animal Food Crop Insects in West Virginia

Leaders: Linda Butler and Joseph E. Weaver, West Virginia

Studies on the distribution and impact of parasites in bio-control of the alfalfa weevil were continued. During 1974, Bathyplectes curculionis and Microctonus colesi remained the most prevalent parasites. B. anurus is established at most release sites, but it continues to be found only in low levels. Weevil larvae parasitized by B. anurus were collected in Pennsylvania in 1974; an estimated 40,000 parasites were released in seven eastern counties of the State. Microctonus aethiops has not been recovered from release sites.

Studies on corn rootworm populations at the West Virginia University farms were completed. Southern corn rootworm predominates in Monongalia County, whereas late season observations in Preston County showed the highest populations to be of Northern corn rootworm. Availability of alternate host plants and late planting dates appear to minimize rootworm effect on corn.

Title: Selection for Aphid Resistance in Grasses of the Genus Digitaria

Leaders: R. H. Ratcliffe and A. J. Oakes, Maryland

Twenty species and two subspecies comprising 372 accessions of Digitaria were screened in the laboratory for resistance to the yellow sugarcane aphid. Six accessions within the species D. diversinervis, D. longiflora and D. friesii and one accession unidentified as to species were highly resistant. In small cage tests where individual aphid survival and reproduction were recorded, aphid populations on the highly resistant accessions were reduced by 75-100% of those on the susceptible check, pangolagrass. Research is now underway to determine the nature of aphid resistance in promising accessions identified in this program. Preliminary results indicate that antibiosis and possibly nonpreference are involved in the expression of resistance.

Title: Nematodes in Forage Grasses

Leaders: Julius Feldmesser, PPI, and S. A. Ostazeski, PGGI, Beltsville, Md.

We are initiating studies of plant-parasitic nematodes in forage grasses. Surveys show that mixed nematode populations (spiral, ring, stunt, dagger, root-lesion, and awl nematodes) damage roots and cause symptoms (chlorosis, wilting, stunting, gradual development of bare spots, lack of reaction to extra water, fertilizer, insecticides) in managed and unmanaged bluegrass, fescue, and orchardgrass, and in zoysia, in the Northeast. Chemical control, mostly in bluegrass, controlled 90-95% of the nematodes, reduced symptoms, and increased grass growth. Nematode genera, probably indigenous and widespread, can exist in unmanaged areas in equilibrium with reduced grass growth rate, and can increase to high densities in managed grass. Their distribution and ability to damage grasses strongly suggest they cause reduced growth and unfavorable ratios between forage acreage and meat and milk production. We need to know

more about nematode-forage grass interactions. We are sampling grass areas and establishing additional chemical control treatments to demonstrate nematode effects. Investigations are planned in pathogenicity studies (single and mixed species); population dynamics; disease complexes; continued use of chemicals, as demonstrations, and where feasible, as part of regular management; and, breeding for resistance. Parts of this work are in cooperation with N. W. Hooven, APGI, James Bond, NI, and John W. Neal, Jr., PGGI, Beltsville.

Title: Taxonomic Revision of Bacillus popilliae and Bacillus lentimorbus

Leader: R. M. Faust, Beltsville, Md.

Taxonomic revision of Bacillus popilliae and Bacillus lentimorbus to the genus Clostridium is suggested from data obtained through enzyme and chemical analysis of the DNA. The G and C content of these "milky spore" disease organisms was 28-29% moles (TM). The G and C content of the DNA of Bacillus species ranges from 32-62% moles (usually 40-47% moles) and Clostridium species ranges from 23-43% moles (usually 26-28%). Correct taxonomic placement of this commercially important Japanese beetle pathogen will allow proper direction in research investigating the sporulation problem in artificial media.



## SECTION III

## PLANT PATHOLOGY RESEARCH

Title: Species of Colletotrichum on Alfalfa in the Mid-Atlantic States

Leaders: J. H. Graham, T. E. Devine, C. H. Hanson, and J. H. Elgin, Jr., Beltsville, Md.

Colletotrichum trifolii is the principal causal agent of anthracnose of alfalfa in mid-Atlantic United States. Races of the fungus were not detected. Local isolates of C. destructivum and C. dematium f. truncata were weakly pathogenic; however, one isolate of C. destructivum from Canada was moderately pathogenic to alfalfa. An isolate of Colletotrichum found in a greenhouse at Beltsville was tentatively classified in the composite group C. gloeosporioides. It produced anthracnose-type stem lesions on experimental strains and cultivars of alfalfa resistant to C. trifolii.

Seedlings inoculated with a mixture of C. trifolii and local isolates of C. destructivum or with C. trifolii and C. dematium f. truncata were significantly less damaged than those inoculated with C. trifolii alone. Similar results were obtained when plants were inoculated with C. trifolii 5 days after inoculation with either of the two weakly pathogenic Colletotrichum spp.

Title: An Agar Plate Method for Selecting Alfalfa for Resistance to Colletotrichum trifolii

Leaders: J. H. Graham, T. E. Devine, J. E. McMurtrey, and D. L. Fleck, Beltsville, Md.

A laboratory method was developed for selecting alfalfa seedlings for resistance to Colletotrichum trifolii. Agar plates were used for growing fungus, for germinating seeds, and for growing the resistant seedlings until they were to be transplanted to soil. Using the cultivar 'Team,' progeny from the surviving seedlings were as resistant to the anthracnose fungus as progeny from plants selected by the previously used procedure of growing seedlings in flats and inoculating with spore suspensions of C. trifolii. Preliminary tests indicated that the method could also be used in screening for Stemphylium resistance and for tolerance to boron.

Title: Leaf and Stem Diseases of Alfalfa

Leaders: E. R. Jones, R. H. Swain, and R. B. Carroll, Delaware

Four Benlate treatments were evaluated on Saranac alfalfa (Medicago sativa) during the 1974 growing season. Experimental plots, established in August 1973, were 20 x 7 ft. A randomized complete block design with three replications was used. Fungicide applications were begun after the second cutting on June 18, 1974. One and two applications of Benlate 50W at two rates (0.5 lb/A and 1.0 lb/A) were compared with an unsprayed control. The fungicide was applied with 40.3 gal water/A with a CO<sub>2</sub> plot sprayer. The incidence of anthracnose (Colletotrichum trifolii), common leafspot (Pseudopeziza medicaginis) and (Leptosphaerulina trifoliana) was determined on July 23, 1974 (third harvest). For disease ratings, 25 plants were selected at random from each plot. The number of stems with anthracnose lesions and the total number of lesions was determined. Percent leafspot incidence was recorded for each treatment.

Data were analyzed by analysis of variance. Since the data did not follow normal distribution, a square root transformation of the disease ratings was made. The number of anthracnose infected stems and the total number of lesions was reduced by Benlate treatment as much as 35% and 36%, respectively. Lepto leafspot was reduced, but the reduction was not statistically significant. All treatments significantly reduced the incidence of common leafspot at the 1% level. Dry matter production of alfalfa was not significantly affected by the fungicide treatments.

Title: Fusarium Root Rot of Forage Legumes

Leaders: K. T. Leath and W. A. Kendall, Pasture Research Laboratory

Studies of Fusarium root rot of red clover and other forage species were continued using the slant-board culture method of growing plants. Aspects investigated were: host response to infection; effects of foliar disease, light, temperature, and clippings on host-parasite interaction; the effect of inoculation site on root rot development; and the effect of host origin on pathogenic host range.

A standard test set of four isolates of F. roseum was established, and a soda-straw method for introducing soil into the slant-board system was devised. Data are being analyzed. Observations indicate that: some isolates can attack only root tips; some isolates attack irrespective of root inoculation site; some isolates showed host specificity, but other did not; short term stresses on the plant did not alter the host-pathogen interaction.

A method was developed for inoculating taproots of mature plants with Fusarium in the greenhouse. This method will be used to corroborate results obtained in slant-board culture experiments. The taproot was severed transversally about 5 cm below the soil surface. A polyester cloth strip, overgrown with the test fungus, was placed against the cut end of the taproot, and the inoculated plant was repotted. After 2-3 weeks, the taproot was split longitudinally and vertical rot development was measured. Isolates of Fusarium were compared for pathogenicity.

Title: Resistance Mechanisms Associated with Foliar Infections of Forage Crops

Leader: R. L. Millar, New York (Cornell)

Both Stemphylium botryosum and S. loti (trefoil pathogen) induce and degrade the trefoil phytoalexins sativan and vestitol. A time course study of phytoalexin induction and degradation in relation to histological development of each fungus in trefoil indicated that sativan and vestitol have little if any significance in the resistance of trefoil to S. botryosum. Another phytoalexin, inhibitory to S. botryosum, was detected but has not yet been characterized.

An investigation of the extent to which cyanogenesis serves as a resistance mechanism in white clover was initiated. Pathogenicity tests and histological studies to characterize the reaction of white clover to several fungi are in progress. A procedure for separating fungal and white clover  $\beta$ -glucosidases involved in cyanogenesis has been developed.

The significance of cyanogenesis to disease resistance of trefoil is under investigation. Histochemical assays of healthy trefoil and assays of extracted tissue suggest the presence of  $\beta$ -glucosidases differing in capacity to release cyanide from cyanogenic substrates. Formamide hydrolyase, by which S. loti detoxifies cyanide, was detected in infected seedlings.

Title: Mechanism of Resistance of Reed Canarygrass to Leafspot Fungi

Leader: R. T. Sherwood, Pasture Research Laboratory

Extensive biochemical and anatomical studies were made to discover the mechanism(s) of resistance of reed canarygrass to leafspot fungi. The drop diffusate technique was used to determine whether antifungal compounds were produced in response to challenge inoculation with



spore suspensions of pathogens which could (Helminthosporium catenarium) or could not (H. avenae, Stemphylium botryosum) infect reed canarygrass leaves. Using solvent extraction, TLC separation and fungal germination bioassay methods, we detected certain antifungal components in the drop diffusate of both inoculated and noninoculated (water control) leaves. No new antifungal compounds were induced. The compounds inhibited Cladosporium sp. but not the above-mentioned species in spore germination tests. Pure samples of alkaloid compounds (N,N-dimethyl-5-methoxytryptamine, 5-methoxytryptamine, and gramine) which are considered to be normal constituents of reed canarygrass, reduced the growth rate of H. avenae, H. catenarium and Stemphylium botryosum when incorporated into agar media at 25 to 200 ug/ml. Tryptamine and hordenine did not reduce growth. Anatomical studies of fungal penetration of leaves revealed for the first time that reed canarygrass responds to penetration attempts of appressorial forming fungi by producing cell wall appositional growths (papillae) in the outer wall of the epidermal cell beneath 80-90% of the appressoria. The papillae enlarged ahead of the penetration peg and apparently prevented penetration by the pegs of noninfecting fungi. Most penetration attempts by the pathogen, H. catenarium, were also apparently stopped by papillae; however about 1% of the H. catenarium appressoria initiated direct penetration, or penetration through poorly formed papillae. Preliminary histochemical tests indicated that the papillae contained lignified wall material.

Title: Influence of Sprinkler Irrigation with Municipal Sewage Effluent on Disease and Insect Incidence and Buildup on Reed Canarygrass

Leaders: K. E. Zeiders, R. T. Sherwood, and R. A. Byers, Pasture Research Laboratory

A field experiment was initiated in May 1974 to determine the impact of weekly irrigation with municipal sewage effluent on disease and insect incidence and buildup on 12 reed canarygrass clones which varied widely in palatability and in reaction to the leaf pathogens Stagonospora foliicola and Helminthosporium catenarium. The spaced plants were located in a narrow strip within a field of corn. Both species were irrigated weekly with 5.1 or 0 cm of sewage effluent.

In September, the incidence of leaf disease was much greater on irrigated than on unirrigated plants. Helminthosporium sativum, H. carbonum, and two unidentified Helminthosporium spp. were isolated from diseased irrigated reed canarygrass. H. maydis Race T was isolated from a weed grass (fall panicum) adjacent to the plots. In pathogenicity tests, two isolates of H. sativum and one unidentified Helminthosporium sp. caused moderate to severe damage on reed canarygrass, oats, Kentucky bluegrass, and orchardgrass. All isolates, including H. maydis Race T (total 7),

attacked Pa. 8703 corn, the variety grown in the irrigated field, but H. sativum caused the most disease. No evidence of blight caused by H. maydis Race T was observed on the irrigated corn. It is concluded that irrigation was a primary contributing factor to the increased incidence of disease on reed canarygrass.

Infestation by cereal leaf beetle larvae in June was reduced by 99%, and fewer stems were killed by frit fly, on irrigated than on unirrigated clones.

Title: A New Disease of Reed Canarygrass Caused by Helminthosporium catenarium

Leader: K. E. Zeiders, Pasture Research Laboratory

In August and September 1973 at the Penn State Waste Water Renovation and Conservation Project, H. catenarium was associated with a leafspot disease on the irrigated regrowth of reed canarygrass after the second cutting, and also on similar unirrigated plants in a nearby control plot. Except for this occurrence, the disease was not observed in unirrigated field plots or space-plant nurseries from 1971 through 1974. Typical lesions were elongated with light tan centers and reddish-brown borders. H. catenarium has not previously been reported to cause disease on reed canarygrass.

In inoculation tests, more disease always developed on plants incubated 72 hr in a dew chamber than on plants exposed 48 hr. Reed canarygrass clones of varying palatability and alkaloid content ranged from resistant to highly susceptible to H. catenarium. Dactylis glomerata and Zea mays were moderately susceptible, and Deschampsia caespitosa was slightly susceptible; no symptoms developed on Bromus inermis, Lolium perenne, and Festuca arundinacea. The disease damage observed on field plants and the severe damage to susceptible inoculated clones showed that H. catenarium is a destructive pathogen, and a potential threat to stands of reed canarygrass during periods of prolonged wet weather. This is the first record of successful inoculations with H. catenarium and of its pathogenicity on four gramineous hosts.

## SECTION IV

## GROWTH, PHYSIOLOGY, AND CLIMATIC EFFECTS

Title: Effects of Soil Temperature Modification on Nutrient Uptake Efficiency and Physiology of Corn

Leaders: G. O. Estes and J. R. Mitchell, New Hampshire

Field studies using no-till and conventional tillage, four rates of broadcast N and two N sources (urea/ammonium nitrate) showed that significantly higher losses of N occur with urea compared to ammonium nitrate when corn is grown under no-till conditions. Relative recovery of N between cultural systems markedly favored the conventional system in 1974. With an application rate of 224 kg N/ha (200 lb/acre) from both N sources, plants recovered 148 kg N/ha (132 lb/acre) when ammonium nitrate was used; 116 kg N/ha (104 lb N/acre) were recovered when urea was applied. Between cultural systems, relative recovery of 175 kg N/ha (156 lb N/acre) and 132 kg N/ha (118 lb N/acre) were obtained with no-till and conventional systems, respectively.

No significant dry matter yield differences occurred in 1974 between no-till and conventional systems when the N source was ammonium nitrate; conventional tillage gave significantly higher yields compared to no-tillage with urea as the N source. Soil temperatures were significantly lower under no-till conditions; early plant development was poorer compared to conventional conditions.

Greenhouse studies with controlled temperature water baths adjusted to give soil temperatures of 15, 20 and 25 C showed adverse effects on corn growth (tops and roots) with the highest rates of banded urea 0-112 kg N/ha (100 lb N/acre) only at the lowest soil temperature. Studies correlating soil temperatures and corn seedling physiology under New Hampshire conditions are continuing.

Title: Forage Physiology, Morphology and Growth

Leaders: G. E. Carlson, N. J. Chatterton, Beltsville, Md.

Tiller initiation in alfalfa and the resulting mobilization of carbohydrates into the root and crown tissues were found to be related to cutting tolerance and survival. Additional competitive advantage



accrues from the increased assimilation rate associated with crown tiller initiation. Although the nonstructural carbohydrates that accumulate late in the fall may not contribute directly to winter survival, they are available to promote early spring growth. Rapid spring growth provides an early, high leaf area index and allows more efficient use of light and moisture and may thereby increase crop production. We conclude that different tillering and carbohydrate accumulation patterns may be used in selection programs to improve survival and production.

Information on additional species supports our hypothesis of a feed-inhibition of photosynthesis in alfalfa. We conclude that the growth of many crop plants is the net result of suboptimal utilization of the inherent photosynthetic potential present in the plants. A significant amount of potential for crop production improvement lies in the unleashing of the photosynthetic potential already present in existing varieties.

Title: Morphology, Physiology and Cultural Responses of Perennial Forages

Leaders: Gary W. Fick, R. R. Seaney, and Charles H. Darrah, III, New York (Cornell)

In comparisons of field grown timothy-alfalfa mixtures and alfalfa, significantly more heaving occurred in 1972-73 in clear alfalfa. In 1973-74 this difference was not evident. In 1974 average forage yields of clear alfalfa were slightly higher than for the timothy-alfalfa mixture. Total seasonal yield of alfalfa in the mixture was only 30% of the clear alfalfa yield. There was no difference between treatments in dry matter yield of broadleaved weeds.

Recent investigations into the mechanisms of winter survival suggest that lipids play a major role as cryoprotectants. Hardy and nonhardy types of alfalfa are being used to investigate the lipid constituents of overwintering organs. Techniques have been developed for the determination of the fatty acid constituents of the major phospho- and glycolipids found in alfalfa. The experimental techniques emphasize the detection of these fatty acids in an unaltered state.

Techniques for the culture of tissues derived from both types of alfalfa on identical media have been developed. These tissues will serve as a model system for the study of winter hardening of alfalfa under natural conditions.

The relationship of aerial plant parts on the hardening response of roots is also being investigated. This study involves the use of reciprocal grafts between the stems and roots of hardy and nonhardy types of alfalfa.

Title: Induction of Phytoalexin Biosynthesis in Tissue Culture

Leader: D. L. Gustine, Pasture Research Laboratory

A system for activating phytoalexin production in callus tissue cultures was developed to provide homogeneous, rapidly growing, nonpigmented tissue to study the biochemistry of phytoalexin formation. Callus tissue cultures from jackbean (Canavalia ensiformis L.) or alfalfa (Medicago sativa L.) hypocotyls flooded with an aqueous spore suspension of Stemphylium sp. or 0.05%  $\text{HgCl}_2$  produced new compounds, as shown by thin-layer chromatography (TLC) of ethanolic tissue extracts. These compounds were not present in tissues treated with sterile water.

To test for fungitoxicity, ethanolic tissue extracts were chromatographed on TLC plates. The plates were sprayed with a spore suspension of Cladosporium fulvum and then with potato dextrose agar. After incubation for 72 hours, fungitoxic compounds were identified by inhibitory zones. Four fungitoxic compounds were detected in "induced" jackbean tissue, while one fungitoxic compound was detected in "induced" alfalfa tissue. These compounds have been tentatively classified as isoflavonoid or pterocarpanoid compounds. They were also produced in detached alfalfa leaves inoculated with fungal spores, and thus appear to be part of the natural response mechanism in plants. One of these compounds has been tentatively identified as medicarpin.

Title: Effects of Slope Exposure on Microclimates and Growth of Grasses and Legumes

Leaders: M. A. Sprague and J. Zublena, New Jersey

Vegetative growth of rye, wheat and oats was greatest on east- and south-facing slopes of a truncate pyramid 37 ft<sup>2</sup> by 8 ft high with a slope of 27° 10' to the horizontal. Growth was least on the north-facing slope with height of rye 6 inches less on May 15 than east and south. The number of seeds per head of rye on N, E and S slopes was 56% less than on W; 1,000 seed weight was 8% more.

With wheat, seeds per head were reduced 65% on the south slope compared with the others. Jointing and heading dates were delayed 10 days to 2 weeks on the north slope compared with east and south, and west was intermediate.

Late summer and fall top growth of clones of alfalfa and orchardgrass was greater on the north slope compared with south. This growth response is closely correlated with soil moisture content during this period. Culms and roots are being analyzed for reserve carbohydrates.

Title: The Effect of Soil Depth and pH on the Availability and Form of Magnesium

Leaders: H. E. Ghazi, R. F. Keefer, and R. N. Singh, West Virginia

Laboratory studies were conducted to determine forms of magnesium at two depths in three West Virginia soils--two often cultivated, and one non-cultivated (Fluventic Dystrochrept, Typic Fluvaquent, Typic Halpludult). Zea mays L. was grown as a test crop to determine availability of soil Mg from different forms at two pH levels. Extraction of soil Mg by different solutions was carried out before and after growth of three crops. Subsoil contained less exchangeable Mg but more Mg associated with clay and primary minerals than topsoils. About 85% to 95% of the total Mg was present in nonavailable forms (clay and primary minerals). Generally exchangeable Mg (extracted with  $\text{CH}_3\text{COONa}$  pH 7) and slowly exchangeable Mg (extracted with  $\text{CH}_3\text{COONa}$  pH 1) decreased with cropping. Very little change after cropping was observed in Mg associated with organic matter, clay ( $\text{HNO}_3$  extractable) and primary minerals (except for one soil). Usually more Mg was absorbed by plants under more acid conditions, except when Mg was applied to soils.

## SECTION V

### WEED INVESTIGATIONS

Title: Weed Control in a New Seeding of Alfalfa - 1974

Leaders: W. M. Dest and R. A. Peters, Connecticut (Storrs)

Several new compounds look promising for weed control on a new spring seeding of alfalfa. The principal weed species was large crabgrass, Digitaria sanguinalis (L.) Scop., with lesser amounts of several broad-leaf weeds.

AC 92390 applied at 1 lb/acre and 2 lb/acre, profluralin at 1 lb/acre, 1 1/2 lb/acre and 3 lb/acre in combination with 2,4-DB at 1 lb/acre, dibutalin applied preplant incorporated at 1 1/2 lb/acre and 3 lb/acre and CGA 17020 at 1 lb/acre and 2 lb/acre gave good to excellent weed control with little or no injury to the alfalfa. EPTC in combination with 2,4-DB, a standard herbicide treatment in new seeded alfalfa, gave excellent weed control. Benefin plus 2,4-DB also resulted in excellent weed control.



Dibutalin applied at 1 1/2 lb/acre preemergence was weak on crabgrass and broadleaf weeds and at 3 lb/acre was only marginal in controlling crabgrass. The 3 lb/acre rate of dibutalin applied preemergence injured the alfalfa. Trifluralin at 1/2 lb/acre and 3/4 lb/acre was weak on crabgrass and also injured the alfalfa. The trifluralin at 3 lb/acre significantly reduced alfalfa yields compared to most herbicide treatments. CGA 24705 at 2 lb/acre and 4 lb/acre was very weak in controlling broadleaf weeds and at 4 lb/acre injured the alfalfa, resulting in a significant decrease in yield.

Title: Evaluation of Herbicides for Use on No-Tillage Corn in a Rye Cover Crop

Leaders: R. A. Peters and W. M. Dest, Connecticut (Storrs)

Glyphosate at 1 1/2 lb ai/acre was slower than paraquat at 1/4 lb ai/acre to act, but completely killed rye (Secale cereale L.) in sufficient time to pose no problem in corn (Zea mays L.) development. Nontoxic weed oil combined with atrazine ec with or without 2,4-D or with simazine ec did not give the degree of rye kill obtained from glyphosate or paraquat. There was sufficient kill to give corn yields significantly greater than the control. However, yields were poor compared to the glyphosate and most paraquat treatments.

Herbicides effective in giving preemergence crabgrass control included simazine wp, alachlor, cyanazine, AC 92390, CGA-24705 and NIA 22486. Metribuzin was very active on crabgrass but depressed corn yields.

Treatments which failed to give early control of crabgrass depressed corn yields. Some materials failed to prevent crabgrass coming in late in the season. No correlation was found between late crabgrass and corn yields. In fact, there may be an advantage in no-tillage fields in having a soil cover of crabgrass which serves as a mulch during the noncropping season.

Title: Weed Control in Pastures and Forage Crops

Leader: D. L. Linscott, USDA-ARS, New York (Cornell)

Bromegrass metabolized 3-(2,4-DP), a metabolite of 2,4-D, at twice the rate of 2,4-D during a 4-day period. Low levels of 2,4-D were found as a metabolite of applied 3-(3,4-DP). Simulated rainfall on bromegrass

prior to treatment severely reduced the metabolism of both 2,4-D and 3-(2,4-DP) in brome grass, but stimulated metabolism in orchard grass and timothy. With no rainfall, order of 2,4-D metabolism was timothy > brome grass > orchard grass. In the greenhouse surface leaf wax production of corn, trefoil, alfalfa and soybeans was inversely correlated with light intensity of FI and MH systems. Acetate-1-C<sup>14</sup> incorporation into lipids by germinating soybean indicated the synthesis of palmitic and stearic acids. Majority of labeled acids found were phospho-glycolipids. Acyl components of phosphatidyl glycerol were highly labeled. 3-nitro-2,4-dichloro benzoic acid inhibited FA synthesis, whereas the amino form stimulated FA synthesis. Metribuzin-pronamide combination controlled weeds satisfactorily in birdsfoot trefoil seed fields. Crownvetch recovered to form excellent fall ground cover after paraquat or glyphosate-triazine-2,4-D treatment and seeding of no-tillage corn. Corn yields, crownvetch recovery and weed control were satisfactory after 1/2 kg/ha glyphosate or paraquat plus 2 kg/ha simazine or atrazine plus 1/2 kg/ha 2,4-D. Glyphosate showed continued promise for weed control during renovation of pastures and hill lands.

## SECTION VI

### MANAGEMENT AND PRODUCTION RESEARCH

Title: Effect of Management Factors on Alfalfa Productivity and Persistence

Leaders: J. B. Washko, K. T. Leath, and A. A. Hower, Pennsylvania

The highest alfalfa yields in 8 years were obtained in the Lehigh Valley, Pa., the center of the alfalfa dehydration industry in the State during 1974. Eleven of 28 varieties produced dry matter yields per acre ranging from 6.01 to 6.38 tons the year following seeding. Arc, a new release by ARS-USDA in cooperation with Pennsylvania, Maryland, Delaware, and North Carolina, was highest yielding. This is attributed to its resistance to the disease, anthracnose, which is a serious problem in the Valley.

In a fertilizer experiment at the same location on a Washington silt loam, dry matter yields ranged from 5.69 tons on the check plot to 6.54 tons per acre on a plot fertilized with 450 lb/acre of K<sub>2</sub>O. The next best yield, 6.43 tons/acre of dry matter, was obtained with an application of 75 lb P<sub>2</sub>O<sub>5</sub> and 300 lb/acre of K<sub>2</sub>O. When sulphate of potash and muriate of potash were compared as sources of potassium, higher forage yields were obtained with muriate of potash than with sulphate of potash.

Title: The Response of Alfalfa to Irrigation, Fertility, and Cutting Management

Leaders: N. A. Clark and J. H. McNemar, Maryland

In early spring 1974 an alfalfa management experiment was established to study the following factors: irrigation, fertility, and cutting management. The irrigation treatments consist of no irrigation and irrigation according to tensiometer readings. Fertility is maintained at one-half, double, and soil test levels. Cutting treatments are: early-bud followed by 30-day intervals, full-bud followed by 40-day intervals, and half-bloom followed by 40-day intervals. The 40-day harvest schedule yielded significantly more than the 30-day schedule during the first season, and the 30-day harvest schedule appears to have weakened the stand. Spring growth in 1975 was much more vigorous from the 40-day interval plots.

Title: Alfalfa Reestablishment in Long-Lived Vigorous Bromegrass Sods Without Tillage or Herbicidal Treatment

Leader: V. Ulrich, West Virginia University

During 1974, data were collected on a 14-year-old stand of bromegrass that had been overseeded with Saranac alfalfa on March 24, 1973, at rates of 0, 10, 15, 20, 25, and 30 lb/acre without prior seed bed preparation by mechanical tillage or herbicide treatment. When animals were not available for grazing the thick bromegrass thatch was burned. Germination, establishment and seedling growth had been excellent; however, the 10 lb/acre seeding rate was clearly inadequate. The 15 lb/acre seeding rate was quite variable and the 20, 25 and 30 lb/acre seeding rate were all very satisfactory in establishing a satisfactory stand of alfalfa.

Plant counts, both in the fall of 1973 and 1974 and during the spring and summer of 1974, revealed differences in plant number in the plot areas that had been utilized for hay production only between the 1 and the 15 lb/acre seeding rate and between the higher rates. Differences were not evident between the 20, 25 and 30 lb/acre rates.

Harvesting of forage in 3 cuttings during 1974 yielded the following hay tonnage and pounds of crude protein per acre for the 0, 10, 15, 20, 25, and 30 lb/acre seeding rates, respectively: 3.96-1019; 5.04-1568; 4.79-1541; 5.08-1671; 4.83-1592; 5.11-1735. The average yield of all bromegrass plots was 4.97 tons/acre with potassium and phosphorus available at high levels in the soil. The average yield of protein was 1621 lb/acre.



Establishment of alfalfa seedlings in the brome grass sections that had been utilized in previous years for hay-grazing studies was decidedly lower and more variable at every seeding rate relative to those in the hay management only. Although the initial establishment of alfalfa seedlings with respect to germination and seedling growth was the same, the more vigorous growth of the brome, attributable to the manuring effect of animals present three times each season during the prior growing seasons provided severe competition for seedling growth in spite of the early June hay harvests during the establishment year.

Regrowth of brome grass was quite vigorous during June, July, and August. Probably a second hay harvest at a 4-inch mower blade height 4 to 5 weeks after the June harvest may have reduced competition. Two factors must be emphasized at this point, however (1) the number of alfalfa plants was much higher at the end of the 1974 growing season than at the beginning and in many plots, and (2) the number of plants was never less than one per square foot for the 20, 25 and 31 lb seeding rates. The severe grass competition on pasture areas may be avoided by harvesting the first cut at the end of May in the Morgantown climate, by harvesting the second and third cut at 5-week intervals and eliminating the nitrogen fertilization after the second harvest. Regrowth of brome grass may then be adequate to provide protection for a late summer seeding of the legume. Several different legume sod establishment systems will be tested during the 1975 growing season.

Title: Summer Seeding Dates for Alfalfa

Leaders: C. S. Brown and R. F. Stafford, Maine

The studies previously reported (1973 Report, p. 58) were continued. A new seeding date study was initiated in 1974, with dates ranging from August 14 to September 10. Observations in spring 1975 indicated complete winterkill of the alfalfa in seedings delayed until August 28 or September 10. The August 14 seeding resulted in alfalfa (Iroquois) stands of moderate density. For all seeding dates, the establishment and survival of timothy (Climax) was excellent.

Title: The Evaluation of Several Alfalfa Varieties, Fertility, and Cutting Management Treatments in Delaware

Leaders: E. R. Jones, R. H. Swain, K. W. Bell, and R. B. Carroll, Delaware

Twenty-three alfalfa varieties including paired plots of anthracnose susceptible and resistant material are being evaluated for dry matter production, root development, stand density and disease incidence. The effects of fertility treatment on disease incidence is being determined on five varieties. Cutting management systems are being compared by evaluating disease incidence.

During the first harvest year dry matter yields ranged from 5.6 to 6.6 tons per acre in the variety trial. Anthracnose resistant material did not demonstrate a high degree of resistance to anthracnose when compared with other varieties. First year response to fertility was not evident. Disease incidence did not appear to be different on various cutting schedules.

Title: Contribution of Several Warm-Season Range Grasses to West Virginia Grasslands

Leaders: J. A. Balasko and R. L. Nestor, West Virginia

Interest in the adaptation and use of warm-season grasses in West Virginia grasslands prompted the current study. The objectives of the study are to conduct a systematic survey of West Virginia to determine the relative abundance of five warm-season range grasses, to describe environments that favor these species, and to compare the importance of these species to that of cool-season grasses. For purposes of the survey, the state was divided into nine areas. Two of these nine areas have been surveyed. Results from these areas indicate that the tall growing warm-season range grasses big bluestem (Andropogon gerardii Vitm.), indian-grass (Sorghastrum nutans (L.) Nash ex Small), and switchgrass (Panicum virgatum L.) contribute very little to grasslands in northcentral and northwestern West Virginia. Little bluestem (Schizachyrium scoparium (Michx) Nash) and broomsedge (Andropogon virginicus L.) occurred more often in plots surveyed but not as frequently as many cool-season grasses.

Title: Evaluation of Perennial Ryegrass-Tall Fescue Hybrids as Forage for Northern Areas

Leader: G. M. Wood, Vermont

Thirty-one perennial ryegrasses were evaluated for cold hardiness in comparison with Kentucky 31 tall fescue, Kenhy ryegrass-tall fescue hybrid, Pennmead orchardgrass, Match timothy, common annual ryegrass, and common Kentucky bluegrass (see 1973 Report, p. 60). Three methods were used: (1) 7 1/2-inch diameter pots buried to rim in gravel outdoors, (2) same diameter pots buried to rim in vermiculite in open-side, unheated greenhouse, and (3) 4 ft x 6 ft field plots. With the exception of S-321 and annual ryegrass no winter injury was experienced by the grasses grown in gravel. Injury to the grasses grown as field plots was minor to severe, with only S-321 and annual ryegrass receiving severe injury. A lesser number of grasses grown in the cold greenhouse, and thus having no snow cover, were all injured to some extent, many severely. Soil temperatures were monitored throughout the winter in both pot experiments. Lowest temperatures recorded were: pots in gravel -9.8 C, and pots in vermiculite (no snow cover) -16.3 C. Average percentage of survivals for the vermiculite experiment are as follows:

Percentage of survival of pot-grown grasses subjected to 1974-75 winter temperatures in an open-side, unheated greenhouse, Burlington, Vt.

Perennial ryegrasses				Other	
Norlea	66	Cropper	24	Kenhy (Hyb.)	64
SYN-D	66	Combi	24	Ky. bluegrass*	50
Citation	65	Splendor	21	Ky-31 tall fescue	38
Pennfine	53	Derby	20	Pennmead orchardgrass	27
Birdie	51	Perma	19		
Majestic	49	Turf-Seed B	18		
SYN-G	45	Epic	13		
Ensporta	40	Barenza	12		
Verna	39	Caprice	11		
Game	34	Pelo	9		
Manhattan	29	NK-100	8		
NK-200	28	Linn	8		
Melle	26	Massa	7		
Sprinter	25	S-321	1		

\* Severely injured by powdery mildew previous fall.



Title: Sand Mine Revegetation with Grasses and Legumes Using Inorganic Fertilizer and Composted Sewage Sludge Soil Treatments

Leaders: J. M. Walker and J. J. Murray, Beltsville, Md.

A sand and gravel mine revegetation study was initiated near Bowie, Md., in the spring of 1974. The study was replicated with 378 individual plots in each of two locations at the mine. The establishment of grasses and legumes (including tall fescue, red fescue, perennial ryegrass, birdsfoot trefoil, and sericea lespedeza) was evaluated after treatments of the mined out land with different rates of screened and unscreened composted sludge--both as a soil amendment and surface mulch, complete lime and fertilizer, and a control. Crop establishment, yield, stand, and nutrient content are being determined. Low rates of composted sludge (25 dry tons per acre--dt/acre) and the complete lime and fertilizer were the best for initial forage cover establishment and a surface mulch of composted sludge was also beneficial. At the end of the first season, the rate of compost supporting best growth of tall fescue, red fescue, and perennial ryegrass was 100, 50, and 50-100 dt/acre, respectively. Leafspot was significantly least at the 100 dt/acre rate. This study on forage performance will run 3 years.

Title: Plant Adaptation to Mineral Stress Factors in Problem Soils

Leaders: C. D. Foy, J. B. Powell, T. E. Devine, and J. H. Elgin, Jr., Beltsville, Md.; and P. W. Voigt, Temple, Texas

The overall objective of this research is to select and/or develop plant genotypes having greater tolerance to soil stress factors that are not economically correctable with present technology. Two important problems in this category are aluminum toxicity in strongly acid sub-soils and mine spoils and iron deficiency chlorosis in calcareous soils.

Forty-two varieties or experimental strains of weeping lovegrass (Bragrostis curvula) differed widely in susceptibility to chlorosis and in top growth when compared in pots of a calcareous soil (pH 7.8). Certain chlorotic strains contained lower concentrations of iron and higher concentrations of manganese in their tops than did nonchlorotic strains. However, other chlorosis-susceptible strains accumulated as much iron (%) in their tops as did the more resistant strains. Thus, both reduced Fe uptake and faulty Fe metabolism may be involved in the chlorosis problem, depending upon the particular strain under consideration. Two strains showing the widest difference in resistance to chlorosis on calcareous soil were also differentially chlorotic (in the same direction) in nutrient solutions containing 1 ppm Fe sideration. Two

strains showing the widest difference in resistance to chlorosis on calcareous soil were also differentially chlorotic (in the same direction) in nutrient solutions containing 1 ppm Fe at initial pH 5.0. Two chlorosis-susceptible strains markedly increased the pH of nutrient solutions within a few days after germination, but two resistant strains either lowered the pH or failed to increase it. This pH changing ability shows promise as a tool in screening large plant populations for tolerance to calcareous soils. Lowering the pH and supplying additional Fe to the solutions prevented chlorosis in susceptible strains.

Weeping lovegrass strains also differed in tolerance to a strongly acid mine spoil at pH 3.5. In selected strains high tolerance to acid mine spoil coincided with high susceptibility to chlorosis in calcareous soil; however, a few strains were susceptible to both media. Preliminary plant analyses indicated that sensitivity to acid mine spoil is associated with an imbalance between Fe and several other elements (Al, Cu, Zn) in plant tops.

Overall results suggest that weeping lovegrass strains can be selected or bred for better adaptation to calcareous soils or strongly acid mine spoil as needed. Preliminary studies indicated that alfalfa populations (and individual clones) and bermudagrass strains also differ in tolerance to acid, Al toxic soils.

Title: Seasonal Distribution of Forage Production

Leader: B. S. Baker, West Virginia

Different areas that had been in permanent sod for a number of years were treated in 1971 with phosphate and/or lime. Since then 3 to 5 cuttings have been made each year in an attempt to determine the seasonal distribution of forage production under various soil and climatic conditions. Most of the forage has been produced in spring or early summer regardless of fertilizer treatment, soil, or climatic condition. When fertility was low, frequently half of the forage was produced by June 15. Areas having cool temperatures and good rainfall distribution produced more total forage and also had a higher percentage of the total forage produced in late summer than did the warmer and dryer areas. Plant species growing in an area was greatly influenced by the level of fertility, and the species present influenced the distribution of forage. In general the areas with appreciable legume content had more uniform forage production during the year than the areas composed almost exclusively of grasses.

Title: Minimum Tillage Pasture Renovation

Leaders: A. M. Decker and R. F. Dudley, Maryland

The following three sod-seeding experiments were seeded into a predominantly Kentucky bluegrass-timothy sod in late March to early April:

Experiment 1 compared five soil openers, three seed placement units, two banded herbicides, and three legume species.

Experiment 2 compared banded paraquat at three rates (0.25, 0.5, and 1.0 lb/acre) and three species (red clover, crownvetch, and trefoil).

Experiment 3 compared the double disc seeding unit with the "zip seeder," broadcast and band application of two herbicides (paraquat 0.5 lb/acre and glyphosate 1.5 lb/acre, and four species (red clover, alfalfa, trefoil, and tall fescue).

The experimental design of each experiment was a randomized block with four replications. Data collected were degree of sod kill, stand ratings 3 and 5 months after seeding, and a single fall forage harvest.

Sod kill was slower but more complete with glyphosate than with paraquat. The 0.25 lb rate of paraquat gave poor sod control; the two higher rates gave adequate control, with the 1.0 lb rate being best. Stand establishment increased proportionately to the degree of sod kill. Total forage yields and yields of the seeded species increased with increased sod kill.

In experiment 3 where band and broadcast applications were compared, significantly fewer weeds existed with the band application, but there was little difference between the establishment of the seeded species. Paraquat was consistently superior to glyphosate in terms of seedling establishment and forage yields of that species; this was true regardless of application method.

Title: Seed Production: Forage Yield and Persistence of Kenland Red Clover Seed Produced in Different Regions

Leaders: A. M. Decker and C. S. Garrison, College Park and Beltsville, Md.

Seed of most improved forage varieties is produced outside their region of origin. The possibility of population shifts in red clover during seed multiplication has been suggested as an explanation for changes in performance of certain varieties. Six lots of breeder, 11 lots of



foundation and 14 lots of certified Kenland red clover seed produced in different geographic regions were compared for forage yield and persistence near College Park/Beltsville, Maryland. The breeder seed was produced at the University of Kentucky; foundation seed in California and Washington, and certified seed in California, Idaho, Oregon and Washington. Three forage harvests were made in 1973 and two in 1974. In the first harvest year, forage yields of only the certified class were significantly reduced. In the second harvest year following seeding there was a significant reduction in yield for both the foundation and certified generations. The average yield on a percentage basis for the three seed categories was breeder 100%, foundation 92%, and certified 86%. There were no significant forage yield differences among seed harvested from the seeding, second- or third-year stands. When forage yields were pooled over seed generations and years of harvest, the Kentucky grown seed produced average hay yields of 3.39 tons per acre, the Oregon seed 3.10 tons, the Washington seed 3.09 tons, the Idaho seed 2.86 tons and the California seed 2.69 tons. Estimates of stand in the first- and second-year of forage harvest showed significant decreases for the certified generation only. There were no comparisons between foundation and certified seed produced at the western locations with seed of similar generations grown in Kentucky. Breeder-foundation-certified seed increase sequences were not available from the latter location.

Title: Seed Production: Esterase Isoenzymes of Red Clover

Leader: D. F. Cole, Fargo, N.D. (formerly at Beltsville, Md.)

Esterase isoenzymes varied from 1 to 7 per seed and 50 different banding patterns were noted in 4 seed lots of Dollard red clover seed representing 2 generations of 2 years of seed production. No consistent pattern or number of bands was associated with a seed lot. These results suggest that esterase isoenzymes are extremely polymorphic in red clover and probably could not be used in varietal identification of red clover or identification of individual seed lots produced in different locations or years.

Title: Seed Production: Shorter Germination Test-Period for Kentucky Bluegrass Seeds

Leader: Vivian K. Toole, Beltsville, Md.

The 28-day germination test-period prescribed for Kentucky bluegrass seeds can be shortened with proper use of light. Shortening the test period is desirable. This would aid in a faster flow of samples

through seed testing laboratories getting information to seedgrowers, seedsmen, and consumers, quicker for labeling and planting purposes and reducing variability in tests. Our results show that the high-energy reaction (HER) exerts greater control over the germination of Kentucky bluegrass seed germination than does the typical reversible phytochrome (P) reaction. Thus, daily illuminations of 2 or more hr causes a reduction in germination at 20 C. At 15-25 C alternation, the temperature prescribed for this species, germination is greatly retarded by 8 hr daily illumination, especially at higher intensity. Seed technologists presently use 8 hr daily illumination. Inhibition of germination depends on the intensity of the 700-750 nm component and is apparently independent of the red-light intensity. Illumination from incandescent lamps and daylight causes greater inhibition than illumination from fluorescent lamps. A daily brief light period eliminates the drag on rate of germination caused by prolonged illuminations. When a daily, brief illumination, from fluorescent lamps is used the test period for Kentucky bluegrass seeds can be shortened by 1 to 2 weeks. This work was done in cooperation with the late H. A. Borthwick.

Title: Seed Production: Maximum Germination of Kentucky Bluegrass and Tall Fescue Seeds Obtained at More Than One Alternating Temperature

Leader: Vivian K. Toole, Beltsville, Md.

In seed testing laboratories 16-8 hr cycles are arbitrarily used for alternating temperatures, however, other cycles are feasible and yield maximum results. Our studies show an inverse relationship between optimum duration and temperature on the warmer part of the cycle. Results with several cultivars of Kentucky bluegrass (Poa prantesis L.) and Alta tall fescue (Festuca arundinacea Schreb.) seeds show that maximum germination depends on the duration of the warmer part of the temperature cycle. Alta tall fescue tolerated 16 hr at 25 C, 8 hr at 30 C, and 4 hr at 35 C without a significant decrease in germination at 15-25 C, 15-30 C, and 15-35 C alternations.

Title: Seed Production: Germination of Sideoats Grama

Leader: D. F. Cole, Fargo, N.D. (Formerly at Beltsville, Md.)

Germination studies with seed from three different sources produced under the same environmental conditions indicate that the official recommended temperature (15 C for 16 hr and 30 C for 8 hr) for seed

germination of sideoats grama was either too low or that the duration of the low temperature was too long. Our results indicate that by increasing the low temperature to 20 C for 16 hrs or reducing the duration of the low temperature to 12 hr a more favorable germination environment is produced.

Title: Seed Production: Control Mechanisms in Grass Seeds  
Determine Germination Results

Leader: Vivian K. Toole, Beltsville, Md.

An understanding of the mechanisms of action of light and temperature on the control of seed germination is essential for the development of better procedures for seed testing and to reduce variability among germination tests. Studies with grass seeds indicate that, although conditions may be optimum at planting, seeds may be thrown into dormancy by high temperature even though germination processes may have been initiated and even progressed part way. Alta tall fescue seeds of a 1973 lot were nondormant and gave maximum germination at 12 C through 18 C constant but rates of germination were highest between 16 C and 19 C. Maximum germination was not obtained over as high a temperature range as rates of germination because of the rapid rates of dormancy induction with increase in temperature above 18 C. Dormancy inducing processes progress at faster rates than those of germination processes and can stop the germination processes even after completion of some part of it (Table 1). After induction of dormancy light became a germination requirement. Red light promoted germination approximately 45% above the dark controls at 25 C and 30 C. Far-red light at the end of the 24 hr period at 15 C failed to reverse the effects of the red light treatment which shows that Pfr (active phytochrome) had completed its action. Part of the germination processes was thus complete. The lower germination at 30 C (69%) than 25 C (84%) following promotion with red light is due to greater induction of dormancy at the higher temperature. The greater dormancy at 30 C is also reflected in the dark controls. Germination of nondormant seeds in darkness at 15 C was 70%. Germination after phytochrome (P) conversion, and even after Pfr had completed its action, remained temperature dependent.



Table 1. Germination of Alta tall fescue seeds treated with 0 and 5 min red light at end of a dormancy induction period,\* held 24 hr at 15 C for completion of  $P_{fr}$  action and then treated with 0 and 5 min far red. The seeds were then transferred to 25 C and 30 C and germination determined 7 days later.

Red treatment before period at 15 C	Far-red treatment after period at 15 C	Germination when seeds held 24 hr at 15 C and then 7 days at	
		25 C	30 C
<u>Min</u>	<u>Min</u>	<u>%</u>	<u>%</u>
0	0 (dark controls)	41	21
5	0	84	69
5	5	77	72

\* Seeds held imbibed at 35 C for 7 days.

Title: Seedling Emergence Response to Soil pH

Leaders: R. W. Duell and R. M. Edelbert, New Jersey

In field plots of Freehold sandy loam ranging from pH 4.2 to 7.4 correlations between pH and emergence of redbud (Agrostis alba) and Canada bluegrass (Poa pratensis) were  $r = + 0.77^{**}$ , and  $r = + 0.59^{**}$ , respectively. In subsequent greenhouse trials Penn sandy loam and Sassafras loam in addition to the above soil were adjusted to three pH levels from 3.4 to 6.5. Emergence of spreading fescues (Festuca rubra subsp. rubra) was adversely affected at pH 4.2. The addition of 448 Kg/ha  $P_2O_5$  did not alleviate emergence impairment. Several species showed no differential emergence from these soils over the range of pH 4.1 to 5.2, either with or without superphosphate. Exceeding a critical level of soil exchangeable aluminum (between 1 to 3 meq/100 g soil) adversely affected emergence of each of the two varieties of spreading and Chewings fescues tested.

Title: Sod-Seeding of Legumes and Pasture Renovation

Leaders: W. L. McClellan, L. D. Hoffman, J. B. Washko, W. L. Kjelgaard,  
W. P. Anderson, and L. L. Wilson, Pennsylvania

The purpose of this work was to determine and demonstrate the methods and results obtained by sod-seeding of legumes and existing grass pastures, as well as to use sod-seeding for establishment of new, pure grass and grass-legume pastures. Results indicate sod-seeding can be used successfully, particularly to add legumes to an existing grass stand, without expensive tillage or increasing the susceptibility of the pasture to erosion. The new legume seedlings are essentially established at the same seeding rate as with conventional methods of tillage and pasture renovation. Both systems are adversely affected by limited rainfall immediately after seeding, as determined by rapidity of stand development and legume-grass composition.

Title: Yield and Quality of "Fall-Saved" Tall Fescue

Leaders: J. A. Balasko and Michael Collins, West Virginia

Field aspects of two experiments designed to study the effects of certain fertilizer treatments and spring-summer cutting schedules on yield and quality components of "fall-saved" tall fescue were terminated during the winter of 1974-75. Chemical analyses included determination of IVDMD, Kjeldahl N, TNC, P, K, Ca, Mg, Fe, Mn, Zn, B, Cu, Al, Mo, Sr, Ba, and Na. When N was applied in mid-August to forage accumulated from mid-June, July 1, and mid-July, winter yields of dry matter and in vitro digestible dry matter were greatest when 60 kg/ha was applied. Yields from plots receiving 30 and 90 kg/ha of N were less. In vitro dry matter digestibility of winter forage decreased from 44.2% to 41.5% as rate of N application in mid-August increased from 60 to 90 kg/ha. All macronutrient element concentrations decreased as winter harvest date was delayed. Concentrations of K and Mg decreased most. Spring-summer cutting schedules had little effect upon crude protein concentrations of forage in winter, but IVDMD values were lower and dry matter yields higher for forage that had accumulated the longest period of time.

Title: Carbohydrate Storage in Ryegrass as Influenced by Fall Management Practices

Leaders: W. Potvin and D. W. Allinson, Connecticut (Storrs)

This study was continued from 1972 and some results were reported last year. Tetrelite and perennial ryegrass were seeded in the fall of 1973. Treatments included fall cutting vs. no fall cutting and nitrogen levels of 0, 50, and 100 lb N/acre. A split split plot layout was used and replicated four times. Plant samples were taken in midwinter. Cutting did not influence TNC or fructosan level while additions of nitrogen depressed both TNC and fructosan levels. For all carbohydrate fractions measured the Tetrelite cultivar had higher levels than the perennial cultivar. Very little winterkill was observed in the 1973-74 winter period. Differences resulting from managerial treatments were minimal. Weather data suggested that environmental effects were quite influential and perhaps could explain the large differences in winterkill observed in the 1972-73 and 1973-74 periods.

Title: The Evaluation of Organic Preservatives for Use with High Moisture Aerobically Stored Forages

Leaders: N. A. Clark and C. C. Sheaffer, Maryland

Propionic acid and ammonium isobutyrate were applied to alfalfa hay at baling time. Several lots of hay ranging in moisture from 25% to 41% were used in this work. The rates of preservative used were: 0.5, 1.0, 1.5, 2.0, 4.0, and 5.0% based on the weight of the hay at the time it was baled. Both preservatives were equally effective in preventing mold growth and heating. One percent preservative was adequate to control mold growth and heating when the hay moisture was 30% or less. When hay moisture was in excess of 30%, mold growth was controlled by 2% propionic acid or ammonium isobutyrate.

Title: Forage Preservation with Organic Additives

Leaders: J. P. Mueller, W. L. Kjelgaard, P. M. Anderson, L. D. Hoffman, T. A. Long, L. L. Wilson, and J. B. Washko, Pennsylvania

Three alfalfa, one orchardgrass hay crops and one timothy low-moisture silage crop were treated with organic preservatives (AIB and Chemstor) during 1973. Hay in experiment I was treated and barn-stored for approximately 7 months. Temperatures for each treatment were monitored



during the first 54 days of the storage period. Following storage, the hay was sampled, and animal acceptability was measured using 56 mature pregnant ewes as test animals. Timothy silage was treated and stored in small metal silos for about 5 1/2 months, then animal acceptability was measured using 42 mature ewes. Results indicate that applications of organic preservatives (0.6% to 2.25% of wet forage weight) to hay may compare favorably to heat drying. Results from the low moisture silage test indicate that organic preservatives may have some feeding advantage over nontreated silage. Two other experiments (experiments II and III) in which second crop alfalfa was chemically treated and baled in conventional bales, large round bales, and stacks provided additional chemical and temperature data.

Title: Ryegrass Variety Evaluation

Leader: D. W. Allinson, Connecticut (Storrs)

Nineteen ryegrass varieties were established in the spring of 1973. Pennmead orchardgrass was included for comparative purposes. The experimental design was a randomized complete block replicated four times. Yields were not obtained in 1973. All varieties survived the 1973-74 winter and most varieties were harvested three times in 1974. Applications of 200, 180, and 210 lb of N,  $P_2O_5$ , and  $K_2O$ /acre, respectively, were made in 1974. Orchardgrass yielded 5.62 tons DM/acre, significantly more than any of the ryegrass varieties. The more productive ryegrass cultivars included Tetrelite, Viva, Linn, commercial perennial, and Vrm - 01412 which yielded 4.54, 4.46, 4.35, 4.29 and 4.07 tons DM/acre, respectively. Yield evaluations will be continued in 1975.

Title: Yield and Nutrient Content of Tilled and Nontilled Corn as Influenced by Different Levels and Sources of Zinc

Leaders: R. N. Singh and O. L. Bennett, West Virginia

Corn (*Zea mays* L.) was grown as a test crop on a Pope soil (Fluventic Dystrochrepts) located near Parsons, West Virginia. Treatments consisted of three rates of  $ZnSO_4$  (0, 4.46, and 8.92 kg/ha) and three of ZnEDTA (0, 2.23, and 4.46 kg/ha) applied at two pH levels (pH 5.4 and 6.5) under tilled and nontilled conditions. Zinc treatments were either banded or broadcast in all possible combinations at the time of seeding. A significant differential response due to different sources and methods of Zn application was found at the two pH levels under both cultural conditions. Both sources increased corn yield under tilled conditions when zinc was broadcast. Nontilled

corn responded significantly to banded and broadcast  $\text{ZnSO}_4$ , but response to ZnEDTA was obtained only when banded with seed. Zinc concentration in leaves was much higher under nontilled conditions than under tilled conditions when Zn was broadcast. No significant increase in Zn concentration of grain was obtained under either management condition from Zn fertilization. Soil analysis indicated movement of Zn from ZnEDTA under tilled conditions. Zinc sulphate did not move through the soil.

Title: Corn Yield and Composition as Affected by pH and Rates of Chicken Manure and Phosphorus Applied to Minesoil

Leaders: R. N. Singh, R. F. Keefer, and R. M. Smith, West Virginia

Chicken manure and phosphorus applications were made to a minesoil derived from shale with pH 4.1 and extremely low in available phosphorus and other nutrients. Chicken manure rates of 0, 5, 10 and 20 tons per acre and phosphorus rates of 0, 50 and 100 lbs per acre were applied to minesoil adjusted to pH 5.2 and 6.5. Two crops of corn were harvested and yield and nutrient content were determined. Yield was increased significantly from chicken manure application. Highest yield was obtained when chicken manure was applied at 20 tons per acre. Phosphorus applications without manure were not effective because of other nutrients, such as N and Mg, were not present in adequate amounts in the minesoil. All crops which received phosphorus and no chicken manure showed N deficiency symptoms. These results indicate that phosphorus and N present in the chicken manure was adequate for two crops of corn. Phosphorus did not seem to be fixed appreciably by the minesoil.

Title: Effect of Sewage Sludge Application on Yield and Composition of Sweet Corn and Field Corn

Leaders: R. N. Singh and R. F. Keefer, West Virginia

Field studies were conducted at two locations--Meanwhile Farm near Berkeley Springs, W. Va., on a Pope silt loam soil (Fluventic Dystrochrepts) and on Wheeling sand loam (Ultic Hapludult) located on the Ohio Valley Experiment Station near Point Pleasant. The sludge applied on Pope soil was low in heavy metals such as Cu, Ni, Cd and Cr and relatively high in N and other nutrients such as Ca, Mg, P and K. Sewage sludge applied on Wheeling sandy loam soil was relatively high in heavy metals such as Cu (3,800 ppm), Ni (14,150 ppm), Cr (4,250 ppm) and Pb (365 ppm). The dry sludge on Pope soil was broadcast on the soil surface at 0, 10, 20 and 30 tons/acre and on Wheeling sandy loam was applied at rates of

0, 9.45, 18.90 and 37.80 tons/acre. A substantial growth response was obtained with only 10 tons of sludge/acre (69 bushels/acre) in comparison with the check plots (49 bushels/acre). Sludge application of 30 tons/acre increased yield to 113 bushels/acre and did not increase the levels of Cu, Zn and Mn to toxic levels. Yield results from the Wheeling sandy loam soil were erratic; corn plants on all plots were stunted and exhibited severe N and K deficiencies throughout the season. This may have resulted from an imbalance of nutrients because this sludge was very high in the toxic elements such as Cr, Ni, Pb, Cu and Zn. Analyses of soils and plants for heavy metals are in progress.

## SECTION VII

### ENGINEERING RESEARCH

Title: Engineering Systems for Forage Crop Production and Use

Leader: D. Mears, New Jersey

The addition to the top of the silo provided enough extra storage capacity to carry the animals through to spring harvest. There was not enough forage produced to take advantage of the extra storage. Therefore, it was again necessary to suspend feeding of silage in the spring for several weeks to prevent the silo being completely emptied before adding the spring forage crops.

The liquid manure system has continued to be satisfactory.

Analysis of ventilation data shows that the ventilation system performs well. However, the capacity of the evaporators on the air conditioning system was not adequate. Therefore, a new zone cooling system was designed, installed and evaluated. Four new evaporators were mounted on the outer wall. Outside air is brought in through these units and discharged through ducts with outlets in the front of the free stalls and at the feeding locations at the silo. The system is capable of cooling the incoming air up to -9.4 C at a maximum ventilation rate of about 8,000 cfm (200cfm/cow).

Carrying the cooled air to where the cows are most likely to have their heads should maximize the benefits of the cooled air. The economic benefits of cooling the air depend upon the increase in milk production.



Title: Circular Dairy Barn

Leaders: M. E. Singley, D. Mears and W. J. Roberts, New Jersey

The addition of 8 ft to the height of the silo should have provided enough additional storage space to carry the animals through the spring harvest. Insufficient forage was produced in the fall to fill the space. Therefore, it was necessary to suspend feeding of the silage in the spring for several weeks to maintain a residual plug.

The liquid manure system has a flush rate of approximately once every 6 minutes. In the usual twice weekly 30-minute flushing period the liquid volume is exchanged in the barn five times each flushing. At this rate the system has been operating with complete satisfaction.

The capacity of the evaporators in the air conditioning system were inadequate and were replaced by four evaporators mounted on the outside wall. A zone cooling system was installed with outlets in the front of the free stalls and at the feeding locations at the silo. The system is capable of cooling the incoming air up to -9.4 C at a maximum ventilation rate of about 8,000 cfm (200 cfm/cow). Carrying the cooled air to where the cows are most likely to have their heads should maximize the benefits of the cooled air.

Title: Regional Project NE-70 -- Engineering System for Forage Crop Production and Use

Leaders: W. L. Kjelgaard (Pa), Chairman, Research Committee;  
G. F. Rehkugler (NY); R. J. Rowe (Me); D. R. Mears (NJ);  
and L. F. Whitney (Mass)

Contributors: The Maine, Massachusetts, New Jersey and Pennsylvania  
Agricultural Experiment Stations

Research has continued on forages as a replacement for concentrate feeds in dairy production. Pellets (7/16 in. dia.) were made from a third cut timothy of about 24% protein and from a second cut clover-grass mixture. The clover-grass mixture made a durable pellet with a bulk specific weight of 45.0 lb/ft<sup>3</sup> and a standard durability index 90.7. By contrast the immature grass formed a softer pellet with a density of 36.7 lb/ft<sup>3</sup> and a durability rating of 86. (Me)

Food grade protein fractions were removed from fresh-cut alfalfa while retaining the basic feed value of the dewatered residue for animal feed. Wet fractionation of leaf protein has been accomplished by ultra-filtration without denaturation. Bitter fractions and other solubles were removed with approximately 50% of the protein recovered. Viscosity of the leaf extract has been determined for various harvest conditions. (Ma)

Improvements were made on the linear programming model of forage production systems and a technical paper describing the model was approved for publication. The Rutgers Circular Dairy Barn with Self-feeding Silo was further evaluated. The liquid manure system has continued to be satisfactory. The ventilation system performs well. (NJ)

Energy for corn silage handling, where transport machines were wagons, a distance of 1 mile, was equivalent to .2 gal. tractor fuel per ton. A similar value for baled hay handling was about .6 gal. tractor fuel per ton. Labor needs for corn silage handling up to 1 mile were 4-7 min. per ton with tower silo storage. Similarly, mechanically loaded baled hay, transported and handled into storage required 6-12 min. per ton. (Pa)

Title: Engineering Systems for Immature Forages

Leader: R. J. Rowe, Maine

Research equipment for pelleting forage material was obtained and tested. Pellets were made from a third cut timothy of about 24% protein and from a second cut clover-grass mixture. Samples were ground in a hammer mill with a 1/8 inch screen and formed through a 7/16 inch pelleter die. The clover-grass mixture made a durable pellet with a bulk specific weight of 45.0 lb/ft<sup>3</sup> and a durability rating of 86. The grass pellets are acceptable but some difficulty occurred in feeding the grass meal into the pelleter. Further work is required to determine an optimum size of grind and feed rate to the pelleter.

A scale-up of the laboratory cross flow dryer was undertaken. A pilot scale model for research use was constructed. This machine has an evaporative capacity of approximately 500 lb of water per hour. Provision was made for controlling air temperature from 37.8 C to 176.5C and changing the amount of recirculated air.

## SECTION VIII

## NUTRITIVE EVALUATION AND UTILIZATION

Title: Project NE-24 - The Nutritive Evaluation of Forages

Leaders: R. F. Barnes, C. F. Gross, D. L. Gustine, G. A. Jung,  
W. A. Kendall, and K. T. Leath, Pasture Research Laboratory

Contributors: J. S. Shenk and P. J. Wangsness, The Pennsylvania State University

Soluble Carbohydrates and Physiological Metabolites. Total nonstructural carbohydrate (TNC), a readily available source of energy in forage of 8 grass species, was 55% higher in spring and 64% higher in autumn than in summer. Low TNC values in summer were associated with high night temperatures and abundant moisture. Frosts may have retarded TNC accumulation in May but enhanced TNC accumulation in October. Perennial ryegrass, timothy, tall fescue and smooth brome grass forage generally contained high levels and Ky. bluegrass forage contained low levels of TNC. Consistent trends for high or low levels of TNC were observed for cultivars of 5 species. Timothy and smooth brome grass produced the most TNC/ha in spring; smooth brome grass, reed canarygrass, and tall fescue produced the most in summer; and tall fescue and perennial ryegrass produced the most in autumn. Only 60 kg N was required to produce near maximum amounts of TNC each season.

Evaluation of Ryegrass and Orchardgrass. In early spring, Pennfine perennial ryegrass and Masshardy and Pennmead orchardgrass (group 1) had cells with large starch granules, small chloroplasts and relatively less material stored as protein and membranes than did Ky. 31 tall fescue and reed canarygrass (group 2). The studies indicate that group 2 cells apparently convert a higher percentage of photosynthetic product into protein and lipid materials, most of which go into chloroplast and cytoplasm structure. In late spring, a relatively high percentage of photosynthetic product of the group 2 grasses apparently is converted to lipids and is stored in the chloroplasts as lipid bodies. This occurs to a much lesser extent in the group 1 grasses. (In cooperation with Dr. R. P. Zimmerer, Huntingdon, Pa.)

Isolation and Identification of Toxic Constituents in Crownvetch.  
(Specific Cooperative Agreement with The Pennsylvania State University.)  
A crystalline compound was isolated from fractions obtained from ethanol extracts of crownvetch. Its melting point, infrared and nuclear magnetic resonance were identical with  $\beta$ -nitropropionic acid (BNPA). Feeding trials (described below) established that this was the toxic compound in crownvetch forage. Further fractionation experiments have led to the isolation of a series of glucose esters of BNPA, and work is in progress to identify their structures.



Mature sheep were given a choice of chopped crownvetch hay or alfalfa hay to determine which forage was most palatable. Wethers were maintained in individual, electronically controlled feeding behavior units so that they could choose between randomly allotted pans containing alfalfa or crownvetch forage. The crownvetch forage contained 0.6% BNPA and had previously produced toxicity in voles, chicks, and pigs. Four sheep consumed a total of 50.5 kg of alfalfa and 1.8 kg of crownvetch forage over the 12-day feeding period. Two of the sheep consumed no crownvetch forage at all. The sheep clearly preferred the alfalfa. Addition of molasses to crownvetch partially masked the constituent(s) responsible for the unpalatability of crownvetch hay.

A second trial attempted to determine if the BNPA content of crownvetch influenced intake. Sheep were given a choice of two crownvetch hays containing 0.7% or 3.0% BNPA. Sheep did not consistently discriminate against the hay with 3% BNPA. This suggests that BNPA content may not be completely responsible for the unpalatability of crownvetch. Unlike nonruminants, the sheep in these studies never demonstrated adverse symptoms when consuming the crownvetch.

Estimating the palatability of forages. The palatability of leaves of tall fescue, perennial ryegrass X meadow fescue hybrid derivatives, reed canarygrass, and some alkaloids that occur in these grasses were evaluated with meadow voles. Palatability was estimated by providing voles with a choice of eating either commercial mouse chow that was available to them continuously or an experimental diet that was available for three 30-minute periods each day. The grasses were fed either fresh or dried. Purified alkaloids were mixed at various concentrations with sucrose or starch and fed as a dry diet. Palatability of 14 clones of reed canarygrass was negatively correlated ( $r = -0.857^{**}$ ) with their total alkaloid levels. Strong positive correlations between tests with materials from the greenhouse and field were obtained for alkaloid content and with one exception for palatability ratings.

Gramine, N,N-Dimethyl-5-Methoxytryptamine, N,N-Dimethyltryptamine, 5-Methyltryptamine-HCl and N-Methyltryptamine were equally unpalatable. Starch was more palatable than sucrose but palatability of the alkaloids was not affected by these carbohydrates.

Leaves of Lolium X Festuca hybrid derivatives that had wide differences in perloline levels did not differ in palatability. In each of three harvests, 'Kentucky 31' and 'Kenwell' tall fescue did not differ appreciably from each other in levels of perloline or palatability.

Minerals. Magnesium studies revealed that (a) forage species and cultivars differ in Mg accumulation, (b) temperature and growth stage affect Mg concentration and some grasses are affected more than others, (c) forage species respond differently to Mg fertilization, (d) marked increases in Mg were observed in some pasture grasses fertilized with

Emjeo and 100 kg Mg/ha, and (e) Mg accumulation is a heritable trait in alfalfa.

Foliar Diseases: Evaluation of diseased forage. The meadow vole was used to assay for antiquality components in diseased alfalfa produced in the greenhouse. The forage was inoculated sequentially with each of five foliar pathogens, and compared with healthy forage for chemical composition, in vitro dry matter disappearance (IVDMD), and weanling meadow vole responses. Foliar disease did not significantly alter chemical composition nor IVDMD of the forage, nor dry matter digested by weanling voles, fed these forages at 60% of their diet. Intake of alfalfa diseased with Uromyces striatus Schroet. was significantly greater, and intake of alfalfa diseased with Stemphylium botryosum Wallr. was significantly lower than that of the respective healthy forages. Weight gains were significantly low for voles fed alfalfa diseased by Phoma medicaginis Malbr. and Roum. and S. botryosum. Neither intake nor weight gain was affected by forage diseased by Leptosphaerulina briosiana (Poll.) Graham and Luttrell or Pseudopeziza medicaginis (Lib.) Sacc. Additional tests are in progress.

Title: Effect of Alfalfa Saponins on Palatability of Rations to Meadow Voles

Leader: W. A. Kendall, Pasture Research Laboratory

In studies of forage palatability with a meadow vole bioassay it was shown that the voles responded to degrees of bitterness which were provided by various concentrations of quinine sulphate. Relatively pure samples of the bitter substance saponin from DuPuits and Lahontan were unpalatable at concentrations that usually occur in alfalfa. Dried plant samples of seven cultivars of alfalfa bred for low saponin concentrations by M. W. Pedersen (USDA, ARS, Logan, Utah) and F. C. Elliott, Michigan State University, were more palatable than comparable genotypes bred for high levels. There were no differences among cultivars within saponin treatments.

Title: Predicting Forage Quality by Infrared Reflectance Spectroscopy

Leaders: K. H. Norris, USDA, ARS, Beltsville, Maryland; R. F. Barnes, Pasture Research Laboratory, and J. E. Moore, Gainesville, Florida

Near-infrared reflectance spectra (1.4 to 2.4  $\mu$ m) were recorded for 87 different samples of ground dry forages. Samples included alfalfa,



fescue, bromegrass, bermudagrass, pangola digitgrass, and mixtures of alfalfa and grasses. Chemical data including crude protein, acid detergent fiber, neutral detergent fiber and lignin as well as in vitro dry matter disappearance and in vivo digestibility and intake were determined on the same samples. Multiple linear regression techniques were used to determine the optimum wavelengths for the reflectance data to predict each of the chemical, in vivo and in vitro analyses. Using second-derivative calculations for the reflectance data at up to nine wavelength points for each component yielded multiple regression condition, coefficients varying from 0.87 for intake to 0.99 for crude protein. The results demonstrate that the infrared-reflectance technique can be used for rapid evaluation of the quality of forages.

Title: Studies on Allelochemical Properties of Crownvetch and Their Effect on Forage Quality

Leaders: D. L. Gustine, R. F. Barnes, Pasture Research Laboratory, and J. S. Shenk, The Pennsylvania State University

Four glucose esters of  $\beta$ -nitropropionic acid (BNPA) were isolated as pure crystals, and designated 7, 9, 10 and 11. Their respective melting points were: 123.5-124, 151-153, 125-125.5, and 158.5-160 C. Elemental analysis and determination of molar equivalents of nitrite ion released from the compounds established that esters 7 and 9 are diesters and 10 and 11 are triesters. Their structures havenot been elucidated.

Preliminary studies on the breakdown of esters in ruminant and nonruminant animals suggested the following: in the vole or pig the esters were partially hydrolyzed during passage through the digestive system, and completely hydrolyzed in the blood. In the cow or sheep, the esters were hydrolyzed and the released BNPA was degraded to unknown products by rumen microflora. It is not known whether this process is sufficient to detoxify BNPA present in crownvetch forage consumed by ruminants.

Information concerning the metabolic fate of BNPA was obtained with  $^3\text{H}$ -BNPA at a 2.0 mg/kg dose; radioactivity was rapidly excreted into the urine within one hour. Radioactivity of brain, heart, kidney, liver, and lung tissue increased within 2 to 30 minutes in each tissue, followed by a decrease, the rate depending on the tissue. Although the liver and kidney tissues had the highest levels of radioactivity at early times, the level in the liver and brain was four times that found in heart, lung, and kidney tissues after 24 hours.

Information was obtained on the effects of toxic doses (100 mg/kg) of BNPA on blood parameters in meadow voles. Intramuscular injections resulted in a significant depression of blood hemoglobin, packed cell volume, erythrocytes, reticulocytes and leukocytes. Animals exhibited



methemoglobinemia, with levels of methemoglobin as high as 82% of the hemoglobin capacity. In view of these findings, it is possible that BNPA toxicity is caused by either high methemoglobin levels, BNPA toxicity to tissue cells, or production of toxic BNPA metabolites.

Title: Nonstructural Carbohydrates in the Spring Herbage of Temperate Grasses

Leaders: G. A. Jung, R. E. Kocher, C. F. Gross, C. C. Berg, Pasture Research Laboratory; and O. L. Bennett, West Virginia

Total nonstructural carbohydrate (TNC), a source of readily available energy, varied from 7 to 32% in spring herbage of eight temperate grasses. TNC in herbage of grass cultivars decreased at different rates as the herbage matured. Herbage of different ages and growth stages from six grasses had similar TNC levels on June 9, indicating that environment affected TNC levels more than stage of growth. These findings refute accepted concepts of TNC relationships for temperate grasses. Nitrogen fertilizer had different effects on amount of TNC produced/ha by grasses.

Title: Mineral Composition of Forages

Leaders: C. F. Gross, G. A. Jung, Pasture Research Laboratory; and D. P. Belesky, The Pennsylvania State University

Phosphorus concentration varied in herbage of 11 grasses from 0.26 to 0.69% and in 11 legumes from 0.27 to 0.47%. Ca:P ratios increased from spring to autumn up to sevenfold for grasses and ninefold for legumes. The difference between Ca:P ratios for two alfalfa cultivars in autumn was greater than the difference between ratios for alfalfa and red clover. Ca:P ratios of grass herbage often was too low and legume herbage too high for optimal nutrition of cattle.

Mineral analyses for 9,000 samples of grass and legume hays and corn silage were characterized for 5 physiographic areas of Pennsylvania.

Title: Effect of Urea Supplementation of Corn Green Chop on Cow's Rumen Fermentation

Leader: H. Fenner, Massachusetts

Past experiments showed that corn green chop, containing zein as part of its protein, provides insufficient nitrogenous matter for maintaining or even increasing microbial growth needed for proper digestion of the feed nutrients in the rumen. A daily urea supplementation of 0, 90, 180 and 270 g to a diet of corn green chop at constant intake was offered to four rumen fistulated cows during the ensiling season of 20 days. Crude protein contents of the rations were 8.6%, 12.1%, 15.6% and 19.1%, with 16.2%, 40.4%, 53.8% and 62.3% of the crude protein in the form of nonprotein nitrogen.

Rations supplemented with up to 180 g of urea per day raised the concentrations of total volatile fatty acids and the proportions of propionic and n-butyric acid and lowered the proportion of acetic acid. The highest urea supplementation did not change these constituents much from the values of the unsupplemented ration. pH proportions of isobutyric, isovaleric, n-valeric and n-caproic acids and concentrations of dissolved sodium, potassium and calcium in the rumen fluid were irregular or unaffected by this urea supplementation. Increased intake of urea raised the ammonia levels and drastically reduced the concentration of dissolved magnesium. The ammonia-magnesium interaction also observed in a previous urea-corn silage experiment is of special interest with regard to the occurrence of hypomagnesemia. Because of the low number of animals used, a repetition of the experiment is needed.

Title: Influence of Graded Levels of Diet Calcium on Milk Production in Holstein Cows

Leaders: C. W. Kim and J. L. Evans, New Jersey

Twenty-four cows were employed in a central composite arrangement of treatments to determine the influence of diet Ca and pH on milk production. Five levels of dry period diet Ca were contrasted with five levels of lactation period diet Ca. Diet Ca in each period ranged from half to twice the mid-levels which were similar to N.R.C. recommendations. Treatments on each cow started at 60 days prepartum, changed as required by design on the day of parturition and terminated at 140 days postpartum. Each cow was assigned to either a sodium or hydrogen phosphate diet (pH). Trends in milk production favored less acid diets through week 13, thereafter more

acid diets prevailed. Carryover influence from dry period (low and high Ca) to lactation period (Low and High Ca) was represented by four outcome groups (lL, hL, lH and hH) with milk productions of 17, 21, 25 and 27 kg/day, respectively. Difference in milk production between hL and lH groups began in week 3. Supplementation of lower Ca corn silage-grain diets with  $\text{CaCO}_3$  in dry and lactation periods resulted in an increase in milk production.

Title: Energy Value of Feedstuffs for Dairy Cattle

Leaders: P. W. Moe and H. F. Tyrrell, Beltsville, Md

Particular attention has been given this year to the development of practical recommendations for feeding standards for dairy cattle. Additional experiments supported the use of the equation  $\text{NE}_{\text{milk}}$  (Mcal/kg DM) =  $0.36 + 0.677 \text{ DE}$  (Mcal/kg DM) to predict the  $\text{NE}_{\text{milk}}$  value of diets when DE concentration is known. Among NE values currently available for lactating cows, Morrison's estimated net energy (ENE) values appear to be more correct than NE values calculated from maintenance digestibility values. Accuracy can be improved however, by adjusting digestibility for intake effects and using the prediction equation given above. For data recorded in tables of feed composition the NE values should be appropriate for a producing animal rather than near maintenance. By contrast digestibility for (TDN) values should be listed as measured at maintenance intake with a second value listed to represent either the digestibility at a higher intake or a rate of change in digestibility with increasing intake.

Title: Influence of Heat and Other Processing Variables on the Utilization of Forage Nitrogen

Leaders: H. K. Goering and D. R. Waldo, Beltsville, Md

Equal portions of each cutting of first harvest alfalfa were processed as either barn-dried hay or dehydrated at 120, 145, or 180 C outlet temperature. Four rations (12% crude protein) were mixed and pelleted containing 50% alfalfa, 24.4% starch, 18.5% straw, 6% molasses, .5% sodium phosphate, and 0.6% salt. Four rams averaging 18 kg initially were ad libitum fed in 4 X 4 Latin-square experiment with total excreta collection. Dry matter digestibilities were 54, 62, 60, and 56% ( $P < 0.05$ ). Digestibilities of nitrogen were 46, 53, 50 and 42% ( $P < 0.05$ ). Nitrogen intakes were 22.0, 23.3, 21.2, and 25.2 g/day ( $P < 0.10$ ). Nitrogen retentions were 4.9, 6.3, 4.8, and 5.1 g/day ( $P < 0.10$ ). Acid-detergent insoluble nitrogen



was 7.7, 7.1, 7.6, and 18.9% ( $P < 0.01$ ) of the total nitrogen. Forty lambs averaging 25 kg were fed for 70 days. Intakes were 736, 821, 803, and 707 g digestible dry matter/day ( $P < 0.10$ ). Gains were 145, 160, 162, and 136 g/day. Digestible dry matter consumed/gain were 5.1, 5.3, 5.0 and 5.4. Dehydrated alfalfa at 120 and 145 C improved digestibility and growth compared to barn-dried or 180 C dehydrated alfalfa.

Frequency of overheated dehydrated alfalfa in commercial channels was determined by collecting 111 samples from 15 states. Using  $> 0.29\%$  acid detergent insoluble nitrogen in the dry matter, 88% were overheated. Pepsin insoluble nitrogen essay indicated that 32% were overheated.

Title: Protein and Nonprotein Utilization by Ruminants

Leaders: R. R. Oltjen and D. A. Dinius, Beltsville, Md

Sixty-four steers were fed a low-quality forage (cottonseed hulls) and a nitrogen-mineral supplement. The supplements were a negative control (no added nitrogen), limited soybean meal and six supplements containing nonprotein nitrogen with or without natural protein to formulate 100% crude protein equivalent mixtures.

Daily cottonseed hull intake, supplement intake and gain (kg), respectively were: negative control, 4.7, 0.39, -.19; limited soy control, 6.6, 0.50, 0.30; 100-urea, 7.8, 0.43, 0.49; 100-biuret, 8.1, 0.67, 0.54; 80-urea:20-fish meal, 8.2, 0.66, 0.67; 80-biuret:20-fish meal, 8.1., 0.61, 0.65; 80-urea: 20-soybean meal, 7.9, 0.58, 0.63; 80-biuret:20-soybean meal, 7.8, 0.69, 0.66.

Steers fed the negative control supplement gained less ( $P < .001$ ) than steers fed all other supplements. Steers fed the restricted soy control gained less ( $P < .01$ ) than steers fed all 100 crude protein equivalent supplements. Biuret and urea were similar in promoting growth. Fishmeal and soybean meal addition to biuret and urea increased ( $P < .01$ ) gains of cattle feed low-quality forage. The performance of the steers was surprisingly good when fed the NPN supplements. An experiment is in progress to determine the effect of urea on feed intake. Varying levels of urea are fed orally or intraruminally. Feed intake, ruminally pH and ammonia and blood ammonia are being monitored.

Title: Alkali-Absorption as a Measure of Cellulose Digestion in Cotton Fiber-Rumen Fluid Systems

Leaders: P. B. Marsh and M. E. Simpson, Beltsville, Md.

Alkali-absorption by a gravimetric centrifuge method serves as a useful adjunct to direct weight loss of the fiber to measure cellulose digestion in rumen fluid-cotton fiber systems. The methodology of the alkali absorption procedure is well known from prior work with cotton fiber being acted upon by fungi and cell-free fungal cellulases. The procedure is basically good to excellent in reproducibility, high in sensitivity, and simple to perform. It is called to the attention of other experimentalists interested in research of either theoretical or applied nature on cellulose digestion in rumen fluid.

Title: Chemical Treatments of Fiber to Increase Digestibility

Leader: L. W. Smith, Beltsville, Md.

There is a wealth of information in the literature starting as far back as the late 1800s on improving the digestibility of fiber by chemical treatment. As many as 20 different chemicals have been tested with varying degrees of success. Sodium hydroxide appears to show the most promise based upon cost, response and safety of handling. Some variables affecting maximal digestibility response upon chemical treatments of fibrous materials are: (1) choice of treatment chemical, (2) contact of chemical and material, (3) moisture content, (4) temperature, (5) chemical composition of material to be treated, (6) particle size, (7) reaction time, and (8) drying of treated fiber. Technology is available to manufacture cellulose that approaches 100% digestibility. Some problems for which research can provide answers are associated with the cost of collection, handling and processing of cellulosic materials, the lower palatability upon feeding and the apparent lowered digestibility of protein from chemically treated fiber.

Title: Effects of Grazing Three Varieties of Tall Fescue by Beef Cattle

Leader: James Bond, Beltsville, Md.

Contributors: J. B. Powell, J. H. Elgin, Jr., N. J. Chatterton, Beltsville, Md.; and A. M. Decker, University of Maryland

(Reported by title only.)

Title: Nutrition and Cell Yield of Ruminant Bacteria that Digest Cellulose

Leader: L. L. Slyter, Beltsville, Md

The unidentified compound(s) present in rumen fluid required as a supplement to basal medium for growth of Ruminococcus flavefaciens strains 1607 and 1625 (Appl. Microbiol. 17:737) can be replaced by tetrahydrofolic acid. These strains also require biotin, thiamine, carbonate, isobutyric, isovaleric, ammonia, cysteine and a mixture of amino acids for maximum growth rates. Medium supplemented with 40% effluent obtained from rumen inoculum supplied a tetrahydrofolic acid-free substrate after 2 weeks of continuous culture in vitro allows some growth (0.15 to 0.18 OD at 24 to 30 hr). Thus, it is concluded that other bacteria synthesize tetrahydrofolic acid in a rumen ecosystem. More biotin than tetrahydrofolic acid may be synthesized in vitro since it was found that the biotin required for growth to 0.60 OD of strains 1607 and 1625 is supplied by effluent obtained from a rumen ecosystem supplied a biotin-free substrate. In other studies six fermentors were inoculated with ruminal ingesta and continuously cultured for 3 weeks while being supplied wood pulp, soybean oil and minerals as pelleted substrate every 37 min. Urea was infused to give a dietary crude protein equivalent of 3.4, 3.9, 5.0, 5.1, 5.9 and 6.5%, respectively. In all cases ammonia was in excess of that required for maximum cell synthesis until isobutyric, isovaleric, 2-methyl butyric, n-valeric and phenylacetic acid were infused. Thus, it is apparent that fatty acids became limiting for cell growth before nitrogen in this trial.

Title: Ruminant Digestion of Energy and Protein

Leaders: D. R. Waldo, H. K. Goering, and G. P. Lynch, Beltsville, Md

Ruminant feed nitrogen use is influenced by its solubility. Nitrogen forms that are very soluble suffer large losses due to ammonia absorption from the rumen. Nitrogen forms that are very insoluble, such as those heat damaged or over protected with formaldehyde, are not readily digested. Methods for assaying protein solubility in the optimum range are being sought. The methods being considered are solubility in sterilized rumen fluid, hot water insoluble nitrogen, one-tenth concentration of Burrough's solution, 0.15 M NaCl, and MacDougall's solution. Soybean meal, alfalfa meal and several other common dairy feedstuffs are being used. Considerable within-feed variation exists.



Variation has been observed in animal performance and whey block intakes. New experiments may show how this problem can be reduced. Liquid whey feeding to large ruminants is still a method of disposal of large whey volumes.

Effects of Pb on young preruminant calves are being studied. Early in life, young calves undergo rapid changes in erythrocyte count along with changes in hemoglobin type and amount. Pb is known to be toxic to young calves and to produce anemia. The responses of the calf to Pb and other nutritional treatments during this period may help give information on the nature of large calf losses to the dairy industry.

Title: Alfalfa as a Source of Human Protein

Leader: L. F. Whitney, Massachusetts

Research continues on the forage system and its unit operations of the process for producing protein directly from alfalfa or any other leafy material. Results from studies on the maceration of alfalfa indicate that dynamic compression is a more effective method for cell rupture than dynamic shear. The amount of energy required is one-tenth as much as for shear methods. This is a key to more economical processing. From a hammer mill with four stages, yields of protein as high as 66% of the plant held total, while allowing mechanical dewatering of 75% of the plant held water of the fresh, ground plant material.

Harvest dates well before the bud stage have provided the greatest yields of protein while this stage of growth has proven to require the least energy to rupture the most cells. More plant science research is needed to optimize alfalfa plant growth and maintenance factors with process engineering needs.

Ultrafiltration continues as a viable unit operation to wet fractionate alfalfa leaf extract into (1) green (chloroplasts) cell walls, etc., (2) protein and (3) bitters (water, sugars, etc.). Biochemical assays are needed to better define the various streams. Denaturation of alfalfa leaf protein is averted by this method. Physical properties of the extract such as viscosity and density have been determined.

In conclusion, the pomace byproduct from expression is a viable forage for the dairy or beef industries. The point of this research is to provide an additional source of income from human protein products while providing essentially the same forage feed (14% protein) value to the dairy feed farmer with a single pass harvesting system.

Extract from mechanical dewatering of freshly-ground green, plant material (through a four-stage hammer mill) contains 66% of the plant protein and 75% of the water.

Title: Utilizing Large Hay Packages

Leaders: L. L. Wilson, J. B. Washko, and W. L. Kjelgaard,  
Pennsylvania

There are several ways of feeding large hay packages, and the feeding method used may determine the total effectiveness of these hay harvesting and storage techniques. The primary objective of this project is to determine the number of acres required to provide winter forage for beef brood cows, where the hay is harvested by four different techniques: (1) conventional rectangular bales, (2) nonstring-tied large round bales, (3) string-tied large round bales, and (4) 1 ton loaf-stacks. Each treatment group contained 10 cows. Other treatments involved in the same wintering comparison were corn stalk stacks (both nontreated and treated at harvest with anhydrous ammonia). Feeding of the hay (orchardgrass-alfalfa) and corn stalk large packages was in a three-sided fence-line feeder. Rectangular bales were fed in a metal hay feeder which ranked high in comparisons of different types of conventional hay feeders. Rectangular hay bales were limit-fed daily. All groups had access to a free choice mineral-protein supplement with a biuret base. Although all other treatments were essentially fed ad libitum, weight losses of cows calving during the experiment ranged from 73 lb for the hay stacks to 186 lb for the ammonia-treated corn stalk stacks. Dry matter contents of the large hay packages ranged from 6 to 13 percentage units greater at feeding compared with the rectangular barn-stored hay bales.

Weight gains of cows calving after termination of the 142-day trial ranged from 8 lb for the nonstring-tied large bales to 129 lb for cows receiving rectangular hay bales. Dry matter offered per head per day for the various treatments were: rectangular hay bales, 19.0 lb; hay stacks, 26.0 lb; nonstring-tied large round bales, 23.1 lb; string-tied large bales 20.9 lb; nontreated corn stalk stacks, 30.7 lb; and ammonia-treated corn stalk stacks, 29.2 lb. Cows expiring during the trial (days 118-125 of trial) from insufficient energy intake during a period of cold, windy weather were nontreated corn stalks (2 head), nonstring-tied bales (1 head) and string-tied bales (1 head). These preliminary results suggest that 20%-30% more acres of forage are required for wintering beef brood cows using large hay packaging techniques, compared to conventional rectangular barn-stored hay bales, if similar weight gains are expected.

Title: The Nutritive Evaluation of Forages

Leaders: J. G. Welch and A. M. Smith, Vermont

The study on particle size decline was continued using forage stems from four grasses harvested at different stages of maturity. The grasses studied were reed canarygrass, timothy, Kentucky bluegrass and brome grass. Ten cm length pieces were placed in nylon bags and submerged in the rumen of fistulated steers. During 10-day periods, it was evident that particle size decline was not sufficient to allow for the passage of the total sample from the rumen, indicating that microbial degradation is apparently insufficient to allow for passage through the remainder of the gastrointestinal tract. Rumination potential of CWC in hay, haylage, and corn silage was compared using dairy steers as the test animals. The results of these trials were in line with previous studies, that is, the level of intake appeared to have a greater impact on the results than any detectable difference due to the method of preservation.

Fecal particle size has been partitioned by using various screen mesh sizes and chemical composition has been determined for each. It appears that as particle size declines the CWC content decreases. Approximately 20% of the fecal dry matter has resisted, to date, any attempt to be recovered even when filtered under pressure. These extremely small particles will be tested in solution to determine their composition.

Natural feeds are being tested for their potential for increasing the osmotic pressure of rumen fluid and its ultimate effect on rumination. Insufficient data have been collected at this time to determine if any of these feeds will give similar results to those obtained using certain mineral salts and polyethyleneglycol. Influence of level of intake on various rumination patterns is currently under investigation.

Title: Effect of Rate and Source of Mg on Yield and Chemical Composition of Orchardgrass

Leaders: R. F. Keefer and R. N. Singh, West Virginia

A field experiment was initiated in 1969 on an established orchardgrass stand on the University Experiment Farm at Reedsville. The Gilpin silt loam soil was well drained and low in plant available Mg. Magnesium was broadcast on the soil surface at the rate of 100 kg of Mg/hectare as  $MgSO_4$  or at 200 kg of Mg/hectare as dolomitic limestone (42%  $MgCO_3$ ). Some plots received zinc as  $ZnSO_4$  at the rate of 5.6 and 11.2 kg of Zn/hectare or as ZnEDTA at the rate of 2.8 and 5.6 kg of Zn/hectare.



Plant magnesium percentage in 1973 was significantly increased to 0.23% by application of  $\text{MgSO}_4$  along with either source of Zn. Dolomite application did not appear to increase leaf Mg content which was only marginal with reference to grass tetany (0.19%). Application of dolomite provided for slightly higher soil acid-extractable Mg compared to the control, especially where Zn was also applied. Considerably higher exchangeable and acid-extractable Mg were found in the topsoil and subsoil where  $\text{MgSO}_4$  was applied even after 4 years compared to nonfertilized plots.

Title: Control Measures for Winter and Spring Tetany in Beef Cows

Leader: R. L. Reid, West Virginia

Trials were begun in 1974 to evaluate (a) different methods of providing Mg in supplements to beef cows through the winter, (b) the effect of Mg supplements vs Mg fertilization in maintaining blood Mg levels in cows during the first 2-3 weeks of spring grazing. During the winters of 1974 and 1975, provision of a free choice mineral mixture containing salt, dicalcium phosphate (or steamed bone meal) and MgO (20% or 30% of the mixture) was not an effective method of maintaining serum Mg at a satisfactory level; cows consumed 1.5-5 g Mg per day from such a mixture.

In cafeteria-type trials to compare palatability of a straight mineral-MgO mix vs mixtures containing 20% dried molasses or 20% ground corn, cows showed a marked preference for the molasses mixture. Consumption of a molasses mixture or a commercial compressed Mg block by cows in the period February-April averaged 8-10 g Mg/head/day. Cows on winter treatments were, in each year, turned in spring on to replicated orchardgrass pastures under three treatments, (a) "high risk" pastures, fertilized with N (168 Kg N/ha) and K, (b) same N:K treatment, + 168 kg fertilizer Mg/ha in the form primarily of  $\text{MgSO}_4$ , (c) same N:K treatment, + commercial Mg blocks (15% Mg). Blood samples were taken regularly from the cows. In both years, Mg blocks maintained higher serum Mg concentrations in cows during the 2-week period following initiation of grazing than in cows on N:K pastures or on pastures fertilized with Mg. Level of consumption from the blocks ranged from 18-26 g Mg/head/day. There was considerable individual animal variability in response to treatment in both the winter and spring periods.

Title: Evaluation of Perennial Grass Pastures with Sheep and Cattle

Leaders: R. L. Reid, J. A. Balasko, and Karen Powell, West Virginia

Grazing trials on perennial ryegrass (Pennfine), smooth brome (Sac), orchardgrass (Potomac) and tall fescue (Ky. 31) with weanling lambs and beef cow-calf units have been continued in 1975. At this point it may be noted that while the ryegrass, orchardgrass and fescue stands have shown excellent persistence, the brome pastures under close grazing have deteriorated and have largely been replaced by other species. The lower DDM (in metabolism trials) and performance of lambs on tall fescue have been examined in studies of composition and mineral availability of the grasses. Balance trials have indicated significant differences in availability and retention of minerals Ca, Mg and P between the grasses, with fescue generally showing lower values.

On pasture samples taken on the same day at intervals during the two grazing seasons, significant differences between grasses in in vitro DDM, N, CWC, ADF, soluble carbohydrate, and hemicellulose content, but not lignin and silica, were noted. Multiple regression analysis indicated that most of the variation in in vivo and in vitro DDM values (80-90%) could be accounted for by determined chemical and mineral components. The ability to predict intake from composition of the grasses ( $R^2$  approx. 55%) was markedly lower. The lower individual animal performance of lambs and calves on tall fescue pastures is at least partially offset by the ability of fescue to maintain beef cows at an approx. 50% higher stocking rate from spring to fall than the other grass species.

Title: Utilization of Magnesium by Lambs Fed Magnesium Fertilized Grass and Legume Hays

Leaders: R. L. Reid, West Virginia; and G. A. Jung, Pasture Research Laboratory

Mineral balance trials on 19 hays of different species, fertilized either with no Mg or Mg (80% as  $MgSO_4$ ) at the rate of 112 kg Mg/ha, and harvested on different dates in Pennsylvania and West Virginia during 1973 and 1974, have been conducted using 6-12 month-old wether lambs. Magnesium fertilization caused a significant increase in Mg concentration, the effect varying with species and with growth stage, but did not affect the concentrations of other minerals. Fertilization did not affect digestibility of dry matter, but

overall forages significantly increased apparent absorption percentage and retention (g/day) of Mg by lambs; again, effects on Mg utilization varied with species and harvest date; an overall increase from 26.8% to 31.8% app. absorption, and from 0.17 to 0.28 g Mg/day retention resulted from Mg fertilization of the forages. Fertilization had no effect on absorption of Ca, P, K or S and no effect on retention of Ca and P. Mean apparent absorption values for all hays were 28.2, 10.3, 7.7, 81.8 and 56.2% for Mg, Ca, P, K and S, respectively. Mineral availability, at equivalent DDM levels, was significantly higher in legume than in grass hays.

Title: Composition and Quality of Tropical Forages

Leaders: R. L. Reid, Amy J. Post and F. J. Olsen, West Virginia

Chemical analysis was completed on 42 species and varieties of grass and 11 legumes, each harvested at 10-12 growth stages, sampled during a 5-month period of rains at Kabanyolo, Uganda. In vitro DDM and the results of in vivo trials had previously been reported. CWC, ADF and AD lignin values increased linearly, and protein declined curvilinearly, with maturation. Significant family, genus and species effects on composition were evident; however, concentrations of CWC, ADF and lignin were generally comparable to those reported for temperate forages. Simple and multiple correlation and regression analyses were run to define relationships with in vitro digestible dry matter (DDM). Over all forages, DDM was significantly correlated with the individual components CWC, ADF, lignin, protein and hemicellulose; there were marked differences between grasses and legumes in regressions between DDM and percent lignin and CWC. Within family, lignin or CWC appeared to be the best single predictor of DDM. In multiple regression analysis, CWC and lignin contributed most to the regression on DDM ( $R^2$  0.74) for all forages. The general equation was:  $DDM (\%) = 109.5 - 0.53 \text{ CWC} (\%) - 2.41 \text{ lignin} (\%)$ . Within grasses, CWC and lignin were of most significance; within legumes, lignin and tannins were most important. Silica content varied with species and growth stage and did not relate consistently to DDM. Of the major minerals, P and Na appeared potentially most limiting for feeding livestock.



Title: Feeding Behavior of Sheep Fed Crownvetch or Alfalfa Forages

Leaders: B. R. Baumgardt and T. A. Long, Pennsylvania

The purpose of this study was to relate differences in intake of two forage species (each cut at two stages of maturity and preserved as haylage or hay) to observed meal patterns and eating durations. The meal-eating behavior of growing sheep fed Pennngift crownvetch (CV) or DuPuits alfalfa (AL) cut at late-bud (LB) or full-bloom (FB) and preserved as haylage (HL) or hay (H) was determined with 24 animals during the last 10 days of a 40-day intake and digestion trial. Each metabolism crate was equipped with a door in the manger that was connected to a micro-switch and event recorder. Numbers of meals, eating duration and dry matter intake were determined daily. Average meal size and rates of dry matter consumption were calculated. Stage of maturity and type of preservation had no significant effect on numbers of meals and forage species differed only slightly. Meal numbers ranged from 12.1 per day for alfalfa LB, HL to 7.1 meals for crownvetch, FB, H. Meal size (g) was not affected by forage species, but haylage fed sheep ate smaller meals. The greater number of meals helps explain the significantly higher dry matter intake of the alfalfa and late-bud forages. The crownvetch fed sheep spent 20% more time in the feeder than the alfalfa fed sheep.

Title: Effect of Conservation Method on Animal Metabolism and Prediction of Intake of Alfalfa

Leaders: B. R. Baumgardt and P. J. Wangsness, Pennsylvania

Voluntary intake of alfalfa hay is often higher than the same forage preserved as silage. Several studies were designed to further elucidate the nature of this intake depression in ruminants. Direct-cut silage (Silage), direct-cut silage dried to the same dry matter as hay (Drysil), heat-dried hay (Hay), hay with water added to give the same dry matter as silage (Wethay), direct-cut silage treated with 0.5% of 2:1 formaldehyde (37%):formic acid (90%) mix at ensiling (Formal), at 24-h wilted silage (Wilted) were made from alfalfa cut and chopped similarly. When fed to lambs ad libitum, Silage, Drysil, and Formal diets had lowest nitrogen digestibilities (52.4%, 51.4%, and 46.6%) with nitrogen balances of -42.1, -9.0 and -13.7 g/head/day. Silage digestible dry matter (50.5%) was lower than Formal (54.5%) and Wethay (57.4%) with other diets intermediate. Voluntary digestible energy intakes (Silage, 190; Drysil, 177; Hay, 202; Wethay, 228; Formal, 225; Wilted, 200 kcal/weight kg .75)

were not significantly correlated with moisture but could be predicted by a multiple regression model having significant contributions from digestibility, dry matter, density, and rate of digestion of cell wall constituents.

The effects of intraruminal infusion of juice expressed from second cutting untreated (Silage) and formaldehyde-formic acid treated (Formal) alfalfa silage were investigated in two fistulated wethers. Infusion of 2.25 liters Silage juice coincident with the a.m. feeding depressed voluntary intake of hay for 1.5 to 9 h and caused distortion in rumen motility. Formal juice had intermediate effects and water no effect. With Silage juice infusions, maximum ruminal fluid of volatile fatty acids (982 mg/100 ml), lactate (1105 mg/100 ml), and osmolality (551 mOsm/kg) were higher than contents previously associated with intake depression. However, synthetic juice with volatile fatty acids, lactate, soluble carbohydrate, pH, osmolality, ammonia, nitrite, and nitrate identical to Silage juice accounted for only 40% of its intake depressing effect when similarly infused. High histamine (184.4 mg/100 ml) and ethanolamine (758.2 mg/100 ml) and other amines may have contributed to the intake depressing effects of Silage juice.

Title: Nutritive Value of Corn Silage Treated with Cold-Flow Anhydrous Ammonia

Leaders: C. M. Lalonde, T. A. Long, P. M. Anderson, and W. L. Kjelgaard, Pennsylvania

Corn silage was harvested at 30-35% dry matter. The ammonia was applied at the base of the silo blower using a "cold flow" applicator. The silage was stored in an air-tight silo. The application rate was 9.85 lb of ammonia per ton of silage (wet basis). Whole and cracked high moisture of 32% to 38% moisture was treated with 2% ammonia, and stored in wooden bins. Sixty-four steers weighing an average of 568 lb were assigned to four rations each replicated twice in a 200-day, 3-period feeding trial. Silage (on as fed basis) composed 60, 40, and 20%; the remainder of the ration consisted of corn grain. The control ration (1) consisted of 61.9% corn silage, 32.3% high moisture corn and 5.8% soybean meal; (2) ration 2 consisted of 65.7% ammonia treated corn silage and 34.3% high moisture corn; (3) 65.7% ammonia treated corn silage and 34.3% treated corn silage 65.7% and ammonia treated cracked corn. Cattle gains were similar on all diets and feed consumption was satisfactory. Each ration was

evaluated in a sheep metabolism trial. Experimental diets were composed of 40% ammonia treated corn silage with the remainder being one of three types of preserved high moisture corn (silo preserved, whole and cracked ammonia preserved) and compared to a conventional corn silage-high moisture corn grain-soybean meal control diet. The nutritive value of untreated and ammonia treated corn silage was also assessed. There were no significant differences between coefficient of digestible energy for all silage-grain rations or silage rations. Ammonia treatment increased the digestibility of the fiber fraction in all treated diets.

Title: Ratios of Alfalfa Hay to Corn Stover for Growing Dairy Heifers

Leader: J. H. Vandersall, Maryland

In an 8-week trial, 15 Holstein heifers weighing approximately 300 kg each were blocked into groups of three. Each animal in the block was randomly assigned to one of the following forage diets:

Group I	2: 1	Stover: Alfalfa ratio
Group II	1: 1	Stover: Alfalfa ratio
Group III	1: 2	Stover: Alfalfa ratio

Forages were fed ad libitum and concentrates adjusted to a 40: 60 concentrate-forage ratio. The concentrate for Group III was ground shelled corn plus minerals. The protein level of the concentrate was adjusted with soybean meal to 11.4% for Group II and 14.2% for Group I.

There were only small differences between groups in intake and weight gain. For groups I, II and III respectively: the average daily grains were, 1002 grams, 981 and 1072; average forage dry matter intake 4.15 kg, 4.37 kg and 4.46 kg, average total dry matter consumption 7.22 kg, 7.58 kg and 7.76 kg. One heifer in group I failed to meet the standard gain of 750 g/day. In future trials the forage concentrate ratio will be widened.



Title: Production, Processing and Feeding of Dried Immature Forages as Grain Substitutes for Ruminants

Leaders: W. P. Apgar, R. J. Rowe, C. S. Brown, and R. N. Krofta, Maine

A cooperative study involving personnel from Animal Science, Agricultural Engineering, Plant Science and Agricultural Economics has been initiated to evaluate the potential for producing and utilizing immature forages as concentrate feed substitutes for ruminants. The agronomic aspect will deal with forage species response to utilization at immature stages of growth. The engineering interests are to develop drying and processing systems adapted to immature forages. Animal nutrition objectives will be to evaluate the nutritive characteristics of immature forages as a substitute for concentrates in ruminant rations. Overall economic analyses will be provided by the agricultural economist.

Title: Forage Soluble N Effects on Cellulose Digestion by Rumen Microorganisms

Leaders: W. P. Apgar and R. E. Goodnow, Maine

The study described in the 1972 Annual Report (p. 67-68) is being continued with additional varieties and numbers of forage samples.

Title: Chemical Additives for Preservation of Hay Bales and Stacks

Leaders: L. L. Wilson, T. A. Long, P. M. Anderson, W. L. Kjølgaard, L. D. Hoffman, and J. B. Washko, Pennsylvania

Contributors: Hesston Corporation, USS-Agri Chemicals, Celanese Chemical Company, and Sperry-New Holland

Evaluation of chemical additives to hay involved temperature monitoring, chemical analysis and acceptability trials. Chemicals used in 1974 on second cutting alfalfa in large bales and stacks

were "Chemstor" and anhydrous ammonia. The Chemstor was diluted with water at the ratio of 2 parts water to 1 part Chemstor by volume. This mixture was sprayed on the windrow prior to baling at a rate of 2 gal of actual Chemstor per ton of hay. Hay averaged 32% moisture when baled. Ammonia was applied to stacks by a unit mounted on the stacking machine and on bales by application to the windrow just prior to baling. In both cases "cold-flow" ammonia was used. For the windrow application ammonia vapors were recycled back into the supply tank and only cold liquid ammonia was delivered to the hay.

Results showed that the ammonia treatments heated more than the Chemstor treatments but not as much as the no treatment checks. Chemstor treatments showed some increase in temperature during the third and fourth weeks. Chemical evaluation of treatments is shown in Table 1.

Table 1. Analysis results 6 weeks after baling (all material baled at 32% moisture, stacks and round bales stored outdoors).

	Treatment	C.P.	C.F.	Pep-Hcl	A.P.
Regular bale	1% chem*	19.78	36.00	5.37	14.41
	1% NH <sub>3</sub>	20.89	34.71	5.14	15.77
Large round bale	1% chem	19.85	37.15	6.44	13.40
	1% NH <sub>3</sub>	18.88	40.77	7.91	10.97
Stack	1% chem	19.68	32.24	4.40	15.28
	1% NH <sub>3</sub>	19.34	38.21	6.00	13.29

\* Chemstor (80% propionic and 20% ascectic acid).

C.P. = crude protein

C.F. = crude fiber

Pep-Hcl = pepsin Hcl (unavailable protein)

A.P. = available protein

The values for available protein (A.P.) were obtained by subtracting pepsin Hcl (unavailable protein) from crude protein (C.P.).

Machine type in the case of pepsin was significant ( $P < 0.01$ ) in favor of stackers and conventional balers. Most heat damage occurred in big round bales. Available protein was also significant ( $P < 0.05$ ) in favor of conventional bales and stacks.

A limited acceptability trial was conducted using treated large round bales and stacks. Six pregnant beef cows were fed these hay packages in

three-sided fence-line feeders. The hay was the only source of feed. Cows had continuous access to the hay, water, and minerals.

Hay in all treatments was not homogenous in quality. There were moldy spots intermixed with nonmoldy hay. There were no observable differences in acceptance of the hay for any treatments. Table 2 summarizes the feeding results.

Table 2. Results of acceptability trials.

	Stack 1% NH <sub>3</sub>	Stack 1% chemstor	Round bale 1% NH <sub>3</sub>	Round bale 1% chemstor
Hay/head/day (1b DM)	26.9	26.3	22.8	28.3
Weighback (1b DM)	153	60	62	74
Hay fed per package (1b DM)	1209	1418	890	1192
No. of cow days per package unit	45	54	39	42
Quality rank (scale 1 to 9)*	3	3	4	4

\* Arbitrary scale with 1 = unacceptable to 9 = highly acceptable.

Title: Evaluation of Pastures for Dairy Heifers

Leaders: E. M. Kesler and J. B. Washko, Pennsylvania

Two plots each, seeded to Iroquois alfalfa-Pennmeade orchardgrass or Pennmeade alone with four 50 lb/acre applications of nitrogen, were rotationally grazed for a third season. There were four grazings on each plot by yearling dairy heifers. Grazing days were standardized to 888 pound (400 kg) animals, based on average body weights during the individual periods on plots. The alfalfa-orchardgrass plots afforded 163 standardized grazing days per acre in 1974; the orchardgrass plus nitrogen provided 211 days. Average gains in body weight were 1.8 and 1.5 pounds per day and dry matter yields were 3.24 and 3.93 tons per acre, respectively.

Three-season averages for the two experimental treatments are as follows:



	<u>Alfalfa- orchardgrass</u>	<u>Orchardgrass + nitrogen</u>
Standardized grazing days per acre	132.0	188.0
Dry matter yields per season (tons/A)	3.5	4.0
Total body weight gains per season		
while heifers were on plots (lb/A)	250.0	260.0
Gain per day while on plots (lb)	1.3	1.7

Title:       Carrying Capacity of Pastures Utilized by Crossbred Cows and Calves in 1974

Leaders:   L. L. Wilson and J. B. Washko, Pennsylvania

The 1974 grazing season extended from May 8, 1974 to November 1, 1974. Due to lack of sufficient nitrogen for top-dressing the potential yielding capacity of the pastures was not reached in 1974. Of the 22 pastures scheduled to be top-dressed with two 50-lb increments of nitrogen each, in the early spring and during the midsummer period, only 18 received the spring application and none received the midsummer application. Despite being short changed on nitrogen, productivity of the pastures was better than expected.

Yields of the various pasture swards, measured in terms of cow grazing days per acre were as follows: Kentucky bluegrass 131, orchardgrass, smooth brome grass, timothy and reed canarygrass swards, 147, the same grasses with volunteered white clover 176, and these tall growing grasses without nitrogen fertilization 82. Thus, the tall growing grasses furnished 16 more grazing days per season than the Kentucky bluegrass. The presence of white clover in the tall growing grass pastures provided almost a month more of grazing (29 days) than the same grasses growing without this legume. A lack of nitrogen either from a commercial source or from a legume resulted in the lowest carrying capacity for the season, 82 grazing days or 65 grazing days less than the tall growing grasses and 49 days less than the bluegrass pastures when the latter two sward types were fertilized with one nitrogen increment of 50 lb per acre in the early spring.

Title: The Comparative Value of Penngift Crownvetch as a Forage for Ruminants

Leaders: M. L. Risius and T. A. Long, Pennsylvania

Crownvetch and red clover were harvested twice during the growing season, preserved as hay and silage and fed to sheep to determine apparent digestibility of the dry matter, energy and protein as well as animal intake. Animal intake and nutritive index values were similar for the eight forage diets. For first harvest, the apparent dry matter digestibilities of crownvetch and red clover hays were similar but the digestibility of crownvetch silage was higher than that of red clover. The digestibility of second harvest crownvetch hay was higher than that of red clover while the second harvest silages were similar in digestibility. The digestibility of first and second harvest crownvetch hay was about the same. The digestibility coefficients of the gross energy of crownvetch were higher than those for red clover.

Except for first harvest crownvetch hay, the crude protein of crownvetch was higher than that of red clover. The digestibility coefficients of the crude protein for crownvetch hay and silage were higher than the corresponding values for red clover but only of a significant magnitude for first harvest silage and second harvest hay. The percentage digestible protein of crownvetch and red clover hay at first harvest were comparable. However, the percentage digestible protein of crownvetch was significantly higher than that of red clover for silage of first harvest and for both hay and silage of second harvest.

Title: Corn Silage Feeding Systems and Their Nutritional Value for Dairy Cows

Leaders: L. S. Bull, C. B. Tamplin, W. S. Kennett, L. F. Little, Maryland

The objectives of this experiment are to:

1. Evaluate the health and production effects of long-time feeding of corn silage to lactating cows.
2. Compare postpartum animal response following a dry period treatment of either corn silage or only hay.
3. Compare fiber (CWC) levels in concentrates (high or low) when fed to lactating cows consuming corn silage.
4. Determine digestibility of diets at various levels of intake.

5. Evaluate the influence of high levels of nonprotein nitrogen on animal performance, using urea and anhydrous ammonia treatments of silage and urea addition to concentrate.

The animals have all been assigned to the study (40 cows, starting at calving). Several have completed the first of three lactations and several others are well into the second. To date there are no differences between treatment groups in milk production, feed intake, or health disorders. Animals fed the high CWC concentrate are producing as much milk as are those fed the low CWC diet. Within treatments, animals fed silage treated with anhydrous ammonia are consuming more silage dry matter than those fed urea treated (0.5%) silage. Digestion trials ( $n = 55$ ) with cows fed at levels of intake up to about five times maintenance produce the following results:  $Y = \text{digested dry matter (\%)}$ ,  $X = \text{dry matter intake (g/day/kg 0.75)}$ ,  $Y = 78.8 - 0.093X$ ,  $R = 0.85$ . Of interest is the fact that the actual digestibility is only about 75% to 85% as high as would be predicted from NRC.

Title: Nutritive Value of Ensiled Cattle Waste

Leaders: H. W. Harpster, T. A. Long, C. M. Lalonde, W. W. Saylor, and L. L. Wilson, Pennsylvania

The nutritive value of ensiled cattle waste (ECW, 60% fresh cattle manure, 40% chopped grass hay) was examined in steer growth (Trial 1) and sheep metabolism (Trial 2) studies. In Trial 1, 48 steers, averaging 258 kg, were assigned to one of six equal groups by weight for a 200-day, three-period feeding trial. The rations fed in Period I were (% of ration dry matter): (1) control (pens 1 and 2) 61.9% corn silage, 32.3% high moisture corn, 5.8% soybean meal; (2) (pens 3 and 4) 69.5% ECW, 30.5% high moisture corn; (3) (pen 5) 100% ECW; (4) (pen 6) 60% high moisture corn, 40% ECW. Average daily dry matter intakes during Period I (56 days on feed) were similar for rations 1 and 3 (6.37, 6.28 kg), higher for ration 2 (6.83 kg), and highest for ration 4 (7.06 kg). The poorest feed efficiency (8.35 kg feed/kg gain) and average daily gain (0.75 kg) were observed in the animals fed 100% ECW.

Feed efficiency and average daily gain were similar for animals fed rations 2 and 4. Animals receiving the control ration exhibited the highest average daily gain (1.36 kg) and the best feed efficiency (4.68 kg feed/kg gain). In Trial II, four wether sheep were assigned to each of six treatments in a three-phase metabolism trial. The treatments were (% of ration dry matter): (1) 41.1% corn silage, 54.3% high moisture corn, 4.6% soybean meal; (2) 50% ECW, 50% high moisture corn; (3) 100% ECW; (4) 60% ECW, 40% high moisture corn; (5) 100% corn silage; (6) 86.4% corn silage, 13.6% soybean meal. Daily dry matter intakes of sheep fed rations 1, 4, and 6 during the ad libitum intake phase of the trial were similar



(1234, 1236, and 1229 g). The lowest intakes were observed in animals receiving rations 3 and 5 (1125, 903 g). Animals fed ration 2 consumed the most dry matter per day, 1246 g. Digestible dry matter values for rations 1 to 6 were 78.0%, 66.9%, 47.2%, 61.4%, 68.6%, and 73.8%, respectively.

Title:        Ensiled Poultry Wastes as a Ruminant Feed

Leaders:    H. W. Harpster, W. W. Saylor, T. A. Long, L. L. Wilson,  
                 Pennsylvania

A laboratory evaluation and a metabolism trial with sheep were conducted to determine the nutritive value of ensiled poultry waste. Caged layer waste and ground, mixed grass hay were combined in the following ratios and ensiled by laboratory methods (fresh basis, W/W): 100:0, 90:10, 80:20, 70:30, and 60:40. A second group of these treatments received ground shelled corn at a level of 5%. The addition of corn had no effect on pH, volatile fatty acids (VFA), or lactic acid content. Based on these preliminary results, four similar silages containing poultry waste were prepared in sufficient quantities for a metabolism trial with sheep. Treatments 1 to 5 included: 60% poultry waste (P.W.), 40% hay; 57.1% P.W., 38.1% hay, 4.8% ground shelled corn; 70% P.W., 30% hay; 60% P.W., 40% oat straw; and 100% ground hay, respectively. Twenty crossbred wethers were divided into five equal groups and randomly assigned to each of the five treatments. Rations 1, 2, and 3 had significantly higher dry matter digestibility coefficients than rations 4 and 5. The addition of corn at ensiling increased the digestibility of crude protein and raised the level of digestible energy, but the increases were not large enough to justify the added cost.

Title:        Effects of Grinding and Pelleting on the Nutritive Value of  
                 Complete Dairy Rations

Leader:     J. C. Derbyshire, Beltsville, Md.

Sixteen milking cows were fed a 16% long hay:84% pelleted concentrate diet to maintain milk production but depress fat test from 3.51 to 2.11%. Cows were randomly assigned to pelleted diets in 4 x 4 latin square trials of 28-day periods. Pellets, fed ad lib, consisted of mature alfalfa at 15% or 30%, 22.5% wheat straw, or 22.5% cottonseed hulls ground and incorporated into the basal pellet. Total milk production was 22.6, 23.0, 22.0, and 22.7 kg/day/cow and percentage of fat was 2.88, 3.05, 3.37, and

3.09%. Fat-corrected milk production was 19.0, 19.6, 19.8, and 19.7 kg/day/cow. Mean fat production was 649, 689, 735, and 698 g/day/cow. Data indicate it takes less wheat straw incorporated into the pelleted concentrate to increase milk fat test than alfalfa or cottonseed hulls.

Title: Nutrition Requirements of Pregnant and Lactating Ewes and Their Lambs

Leader: I. L. Lindahl, Beltsville, Md.

In 1973-74, a group of 15 ewes were fed a diet containing 79% to 95% dehydrated cattle manure (I), and 2 groups of 30 ewes each were fed diets containing either 38.5% to 53% manure (II) or 82% to 96.5% alfalfa (III) during breeding and gestation. All diets were pelleted and alfalfa or manure to concentrate rations were adjusted to meet nutritive requirements for specific stages of gestation. Diet I was fed ad lib. Diets II and III were fed according to NRC requirements. Conception rates were 86.7%, 90.0% and 93.3%, respectively. Pregnancy failures between 70 and 125 days of gestation were 10.0%, 5.0% and 4.8%. Abortion rates between 126 and 140 days were 20.0, 10.0 and 3.3%. Three pregnant ewes were slaughtered from group I and 6 each from groups II and III. Two pregnant ewes died from each of groups II and III. The percentage of ewes that lambd with live lambs at 2 weeks after parturition was 83.3, 75.0 and 94.7, respectively.

A device was developed which allows for the intraruminal infusion of concentrated volatile fatty acids without the damaging effects of the concentrated acid on the rumen epithelium or the artifacts which result from ingesting the acids in dilute aqueous solution. Infusion of 1 kg of acetic acid per day in heifers fed basal rations slightly above maintenance decreased rumen pH but had essentially no effect on osmolarity or Na concentrations of rumen fluid. K concentrations, however, were increased by infusion directly with the proportion of concentrate in the basal ration.

Title: Utilization of Digestible Energy in Cattle

Leaders: H. F. Tyrrell and P. W. Moe, Beltsville, Md.

Experiments to evaluate the effect of intraruminal infusion of acetic acid on efficiency of energy utilization by mature nonpregnant dry cows have been completed and summarized. Infusion of acetic acid into the rumen disrupts fermentation of the basal ration and no method has been

found for introducing this end product of digestion which will completely eliminate alteration of rumen function. Breakdown of cell wall constituents is depressed by acetate infusion and the magnitude of the response is greater for high grain rations than for rations high in forage. Recognizing that interpretation of energy balance experiments may be biased by the influence of infusion of acetate on fermentation of the basal ration, the data obtained imply that efficiency of utilization of acetic acid for fat synthesis is 26% when added to a forage basal ration compared to 68% when added to a high grain basal ration. This is consistent with the hypothesis that adequate glucogenic precursors must be available for efficient fat synthesis from acetate. Additional experiments are underway to test this hypothesis by the simultaneous infusion of acetate into the rumen and glucose into the abomasum of yearling Holstein heifers consuming basal rations both low and high in forage.

Title: Utilization of Plant and Animal Waste Products and of Forage by Beef Cattle

Leader: D. A. Dinius, Beltsville, Md.

Monensin, a polyether antibiotic, was blended with a 90% chopped orchardgrass diet at levels of 0, 11, 22 and 33 ppm and fed to steers to determine its effect on dietary carbohydrate and nitrogen digestion, on ruminal VFA concentrations and ratios, and on numbers of ruminal microbes. In vivo digestion of dietary compounds (4 steers per treatment) was as follows: dry matter 64.4, 63.5, and 67.8% for the 0, 11, 22 and 33 ppm treatments, respectively. Monensin did not affect ( $P > 0.05$ ) the digestion of these dietary components. Total ruminant volatile fatty acid concentration was not affected by feeding monensin, but the molar proportion of acetate decreased ( $P < 0.01$ ) from 66.7 to 61.3% and that of propionate increased ( $P < 0.01$ ) from 20.1 to 26.1% with increasing levels of the additive. No other volatile fatty acids were affected. Neither the numbers of protozoa, total bacteria nor cellulolytic bacteria in ruminal fluid were affected by feeding up to 33 ppm monensin.

Wilted orchardgrass was ensiled with or without paraformaldehyde preservative and subsequently fed to growing beef steers. The treated silage did not improve growth rate as has been observed in previous studies with dairy heifers.



SECTION IX  
SILAGE RESEARCH

Title: Corn Variety Silage Evaluation

Leader: James R. Justin, New Jersey

A total of 128 corn varieties from 16 sources were grown at the Soils and Crops Research Center at Adelphia, N.J. Planting date was May 1. Fertilizer was applied at the rates of 800 lb 10-10-10 broadcast and disced with 150 lb 18-46-0 banded with the planter. Populations were corrected to 24,000 plants per acre. Rows were 30 inches at center. Plots were harvested in early September with a one-row forage chopper.

Results were reported to New Jersey farmers in tons of silage per acre at 35% dry matter, and dry matter found at harvest. These results were reported with grain corn data from evaluations at three locations in the state.

Title: The Relationship Between Corn Silage Production and Grain Yields of 13 Corn Hybrids

Leaders: E. R. Jones and R. H. Swain, Delaware

Research was conducted to determine if corn hybrids with high grain yields grown on the Delmarva Peninsula also yielded highest dry matter and total digestible nutrients. Each of 13 seed corn companies submitted a hybrid which they felt was optimum for silage production under our growing conditions. All varieties were seeded May 8, 1974 and thinned to 24,500 plants per acre. 1950 lb of 10-10-10 per acre was disced in, carbofuran was applied in the furrow and an atrazine-Lasso mixture used for weed control.

Silage yields ranged from 9.8 to 20.1 tons per acre at 30% dry matter. Grain yields ranged from 71 to 140 bushels per acre at 15.5% moisture. In general those hybrids having high silage tonnage also had high grain yields but there were exceptions. One hybrid produced 18 tons of silage per acre but only 92 bushels of grain.

The data demonstrated that silage and grain yields may not be related for all hybrids. At harvest time it was noted that no definite relationship existed between moisture in the grain, black layer formation,

percentage of dead leaves or percentage of ear drop. This points out the difficulty of determining harvest date using only one of these criteria. Total digestible nutrients per acre have not yet been determined.

Title: Nitrogen and Carbohydrate Digestion and Metabolism in Ruminants Fed Corn Silage Based Diets

Leaders: L. S. Bull, M. I. Poos, W. G. Helferich, T. L. Hollenshade, T. Sweeney, Maryland

The objectives of this research are to investigate, in animals fed diets based on corn silage (and through the use of in vitro fermentation systems:

1. The effect of protein solubility on ruminal carbohydrate digestion, protein synthesis, and animal performance.
2. The effect of level of intake on ruminal digestion of carbohydrate, rate of protein digestion, and microbial synthesis.
3. The effect of the variables in (1) and (2) on the dynamics of carbohydrate digestion and turnover in the rumen.

Two types of experiments are being conducted (in vivo and in vitro).

In vivo - Ruminal fistulated lactating cows were fed either a low protein control diet (corn silage, corn meal; 9.4% C.P.) or the control raised to 15% C.P. with either soybean meal or urea, in a 3 x 3 latin square arrangement of treatments, with two replicates. Intake, digestion, nitrogen balance, milk production, ruminal ammonia, pH, and VFA data were gathered. Analyses of these results are incomplete at this time, but raw data suggest that the level of urea needed to raise the control diet to the protein-adequate level was too great to produce maximum intake.

A second trial is to follow in which cows will be fed a diet of 11.5% C.P. as control, with the same treatments.

In vitro - Diets based on the control ration fed to cows in the in vivo study are being fed to continuous culture fermentors, at two levels of intake (turnover), to study the influence of protein solubility (urea, corn gluten, Dehy-100) and turnover rate on microbial protein synthesis and carbohydrate digestion (rate and extent).

Included with this study is a comprehensive evaluation of microbial analysis methodology. The range in protein solubility of the various diets is from approximately 20% (corn gluten) to 70% (urea). Data on chemical characteristics (pH, gas composition, VFA) and microbial population (gross morphology) are being gathered.

Title: Sunflower Silage for Dairy Animals

Leader: J. H. Vandersall, Maryland

Because sunflower silage is very wet, poultry litter was added at the time of ensiling to absorb moisture. The floor-litter was used from pullet replacement houses and was ground. The litter was added at the rates of 150 and 300 lb per ton of green material.

Runoff was reduced. Intake and digestion trials are in progress. Preliminary observations indicate the addition of the litter did not reduce dry matter intake of the silage.

Title: Formaldehyde and other Additives for Ensiling Forages

Leaders: D. R. Waldo, J. C. Derbyshire, and H. K. Goering, Beltsville, Md.

Orchardgrass forage was ensiled either as control (C) or with 0.47% of a 1:2 mixture of 90% formic acid: 37% formaldehyde (F) in fresh forage. The dry matter of the C and F silages contained 2.2 and 2.3% N which was 35 and 50% hot water insoluble plus 17 and 6% volatile. Each silage was fed without additional N (O) and with 20% additional N either as urea (U) or protein (P) from formaldehyde-treated soybean meal. Heifer gains were: CO, 0.29; CU, 0.29; CP, 0.52; FO, 0.51; FU, 0.48 and FP, 0.73 kg/day. Daily intakes were: CO, 237; CU, 228; CP, 252; FO, 253; FU, 254 and FP, 276 kcal DE/kg<sup>3/4</sup>. The Mcal DE above maintenance/kg gains were: CO, 21; CU, 19; CP, 14; FO, 14; FU, 15 and FP, 12. More true protein or less soluble N was the primary factor improving performance.

Whole corn plant was ensiled with isonitrogenous quantities of either urea, soybean meal (SBM), dried poultry manure or juice pressed from dairy cattle manure. Crude protein was 11.4, 10.8, 10.4 and 11.1% of DM and hot water insoluble N was 33, 50, 41 and 46% of total N. N digestibilities were 58, 49, 48 and 44%. Daily nitrogen retentions were 0.8, 0.1, 3.1 and 2.1 g. Daily gains of sheep were 3, 48, 132 and 101 g. Dried poultry manure improved intake and gain.



## SECTION X

## ENVIRONMENTAL RESEARCH

Title: Physiology of Cold Tolerance of Alfalfa

Leaders: G. A. Jung, Pasture Research Laboratory; M. Krasnuk,  
and F. H. Witham, Pennsylvania

Dehydrogenase levels in alfalfa were greater in winter than in summer, and coincided with increased levels of soluble protein and sugars, and cold tolerance. Glutamate, NAD-malate and NADP-malate dehydrogenases were fairly stable to freezing, whereas isocitrate, lactate, 6-phosphogluconate, and glucose-6-phosphate dehydrogenases were labile.

Title: Development of Models to Predict the Effects of Agricultural Production on Quantity and Quality of Water from Agricultural Watersheds

Leader: H. N. Holtan, Beltsville, Md.

The model of watershed hydrology is used as the basic routine in ACTMO (Agricultural Chemical Transport Model) to predict potentials of water pollution by transport of chemicals used in agriculture. The model was released for testing and further refinements. The hydrologic model, USDAHL-74 Revised Model of Watershed Hydrology, has been adapted for optimization of input parameters based upon applications to rainfall and runoff records available in ARS. Also, a concept of component testing was developed in which the watershed model is applied to compute the hydrologic accounting of small plots, lysimeters, and even to match the records at point soil moisture stations. The purpose of this research is to derive plant and soil parameters for use and computations of watershed hydrology. This is a significant step in bridging the gap from point and plot sources data to applications in large area computations.

Title: Revegetation of Acid Mine Spoils in Appalachia

Leader: W. H. Armiger, Beltsville, Md.

A number of forage species, both grasses and legumes, have been grown successfully on acid mine spoils that ranged in pH from 2.8 to 4.0. The forage species have afforded excellent ground cover for erosion control and spoil stabilization to the disturbed land areas. Selected spoil amendments have modified the toxic spoils to the extent that it has been possible to produce 6 tons dry matter/acre, annually. It has been shown that grasses and legumes may be established on steep outer slopes, 60 to 65% angle of repose, and 100% survival recorded for 4 years.

Grass species that have been grown under the toxic environment include: orchardgrass, weeping lovegrass, timothy, Ky 31 tall fescue, red fescue, bermudagrass, bromegrass and switchgrass. Likewise, the following legumes have been grown: ladino clover, accessions of red clover, birdsfoot trefoil, crownvetch, hairy vetch, crimson clover, alfalfa, flat pea, kura clover and zigzag clover.

The first step in land reclamation of strip-mined areas is the establishment of ground cover for rapid erosion control and spoil stabilization. It appears that forage species play an all important role in much needed land conservation techniques.

Title: Air Pollution Effects on Quality of Forage Nutrition

Leader: R. K. Howell, Beltsville, Md.

Experiments were conducted to determine the effects of ambient oxidants, ozone, and sulfur dioxide on nutritional quality of forage. When Kenland red clover was grown from seed to bloom in unfiltered air of greenhouses, foliage was damaged about 60%, percentage of protein was decreased, percentage of carbohydrate and crude fiber was increased, but vitamin A and percentage of lipid were unchanged. Clover plants exposed to 0.5, 1.0, and 1.5 ppm SO<sub>2</sub> for 2 hr developed about 10, 30, and 60% foliar injury. At the highest concentration of SO<sub>2</sub> vitamin A was reduced. None of the treatments altered percentages of lipids, and the changes in other constituents were nonlinear. Exposure of Team alfalfa to either 20, 25, or 30 pphm ozone for 4 hr caused about 20, 30, and 60% foliar injury. The 25 and 30 pphm concentrations reduced vitamin A content significantly, but the treatments did not significantly affect other quality factors.

Title: Effects of Sewage Sludge on Soils and Yield of Soybeans and Corn

Leaders: A. M. Decker, J. M. Walker, R. L. Chaney, and D. C. Wolf, Maryland

Corn and soybeans were grown for the third season on soils that had received 0, 25, 50, and 100 dry tons per acre of digested sewage sludge. One half of each sludge treatment was fertilized with 80 lb each of  $P_2O_5$  and  $K_2O$ ; the zero sludge corn plots also received 160 lb N. Data being collected are: (1) yields of beans, corn grain, and corn silage; (2) nutrient status of the soil (including heavy metals); (3) chemical composition of crops grown; (4) effects of sludge on soil structure; and (5)  $NO_3-N$  levels in the soil.

Corn grain yields were significantly higher with each increased sludge rate; there was no difference between the 25-ton sludge rate and the fertilized check. Fertilizer application did not significantly alter grain yields where sludge had been applied. Silage yields tended to increase with sludge rates, but these differences were not significant. Soybean yields were essentially the same for the check and 25-ton sludge rate, and significantly lower than the 50- and 100-ton rates which were essentially the same. On soil samples taken May 1974, nitrate-nitrogen contents were higher at the 0-6 inch level with all sludge rates, and at lower depths for the two higher sludge rates, but these increases were relatively small.

Title: Sewage Sludge Utilization in New Jersey Pine Barrens

Leader: Robert W. Duell, New Jersey

In the second year of surface applications of secondary digested domestic sludge, grass receiving 10 tons dry matter per acre per year began to appear adequately fertilized, while 40 tons/acre/year (requiring 20 applications) caused some smothering. The 20 tons/acre/year rate produced highest harvest of Midland bermudagrass and rye; both taken as green-chopped forage. Rye drilled over bermudagrass germinated well even with inch-deep coverage of liquid sludge (5% DM). Deer and rabbits grazed sludge-treated rye and cool season grasses readily in certain seasons but utilized little of the Midland bermudagrass. Wildlife was not repelled by surface-applied sludge, and grazed 40 ton plots more closely than 20 ton plots of cool-season grasses. Orchardgrass dominated fenced sludge-treated plots, but constituted less than 5% of unfenced mixture of cool-season grasses receiving 20 tons, and less than 1% of the mixture receiving 40 tons. Kentucky bluegrass increased markedly with the closer grazing that wildlife imposed on the 40 ton plots.



Heavy-metal uptake by grasses on three limed soils does not appear excessive. Sludge-treated pine, oak and huckleberry showed a growth response to 20 tons/acre/year of sludge. These plants showed appreciable differences in mineral contents of leaves between sludge-treated and untreated plots.

Title: Movement of Heavy Metals in a Food Chain

Leader: D. J. Horvath, West Virginia

The seasonal lead studies reported last year have been extended and confirm the earlier experiment. Feeding voles for 30 days on diets of summer-cut fescue, winter-cut fescue or a 50/50 blend provided 4, 9 or 14 ppm Pb. Soft and hard tissue Pb were positively and rectilinearly related to diet Pb level and Hb and hematocrit depression were likewise rectilinear.

Feeding littermates for an additional 30 days on control rations permitted tissue levels to decline, presumably largely by excretion of Pb. Rates of decline were more rapid for soft tissues studied than for hard tissue.

Evidence of plant Cd increase due to sludge (not season as in the case of Pb, above) has been found in several plant species.

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## RECIPIENTS OF GRADUATE DEGREES - 1974

M.S. Degree

<u>Name/Institution/Advisor</u>	<u>Thesis title</u>
Adalla, J. J. Rutgers Univ. M. A. Sprague	Effect of cutting frequency on dry matter yield, persistence of stand and total available carbohydrates in the roots of alfalfa ( <u>Medicago sativa</u> L. var. Vernal).
Bae, D. H. Univ. Vermont A. M. Smith	Effect of hay intake levels on rumination patterns in sheep.
Cook, R. W. Univ. Massachusetts L. F. Whitney	Effects of processing variables on the viscosity of alfalfa leaf extract.
Edelberg, Ralph Rutgers Univ. R. W. Duell	The effect of soil pH on the emergence and growth of grasses and legumes.
Everett, H. W. Univ. Maryland A. M. Decker	Establishment of small-seeded legume in sod with new minimum tillage equipment and herbicides.
Kabuga, Joseph Univ. New Hampshire J. B. Holter	Utilization of energy and nitrogen of urea versus soybean meal as supplements for corn silage.
Khawaja, A. R. West Virginia Univ. L. Buttler	Survey of the corn rootworms <u>Diabrotica longicornis</u> Say and <u>D. undecimpunctata howardi</u> Barber in northern West Virginia.



Name/Institution/AdvisorThesis title

Lea, H. Z.  
Univ. New Hampshire  
G. M. Dunn

Stomatal diffusion resistance and stomatal behavior in tetraploid, hexaploid and octoploid plants of Bromus inermis Leyss.

Liu, Beverly W. Y.  
Cornell Univ  
G. W. Fick

Response of alfalfa (Medicago sativa L. ) to natural feeding by the alfalfa weevil (Hypera postica Gyllenhal).

Schmit, R. M.  
Rutgers Univ.  
R. W. Duell

The morphology, turf performance and breeding behavior of fine-leaved fescues (F. rubra spp. rubra L., F. rubra spp. Tricophylls Gaud., F. rubra spp. commutata Gaud., F. longifolia Gaud., and F. tenuifolia Sibth.).

Sheaffer, C. C.  
Univ. Maryland  
N. A. Clark

The evaluation of organix acids as preservatives for stored forages.

Stratton, C. L.  
Univ. Connecticut  
G. F. Griffin

Effects of soil treatments on cadmium and lead retention by soil and subsequent uptake by plants.

Stutzman, R. D.  
Penn. State Univ.  
J. B. Washko

Legume establishment in grass swards by sod-seeding methods.

Taylor, R. W.  
Univ. Connecticut  
D. W. Allinson

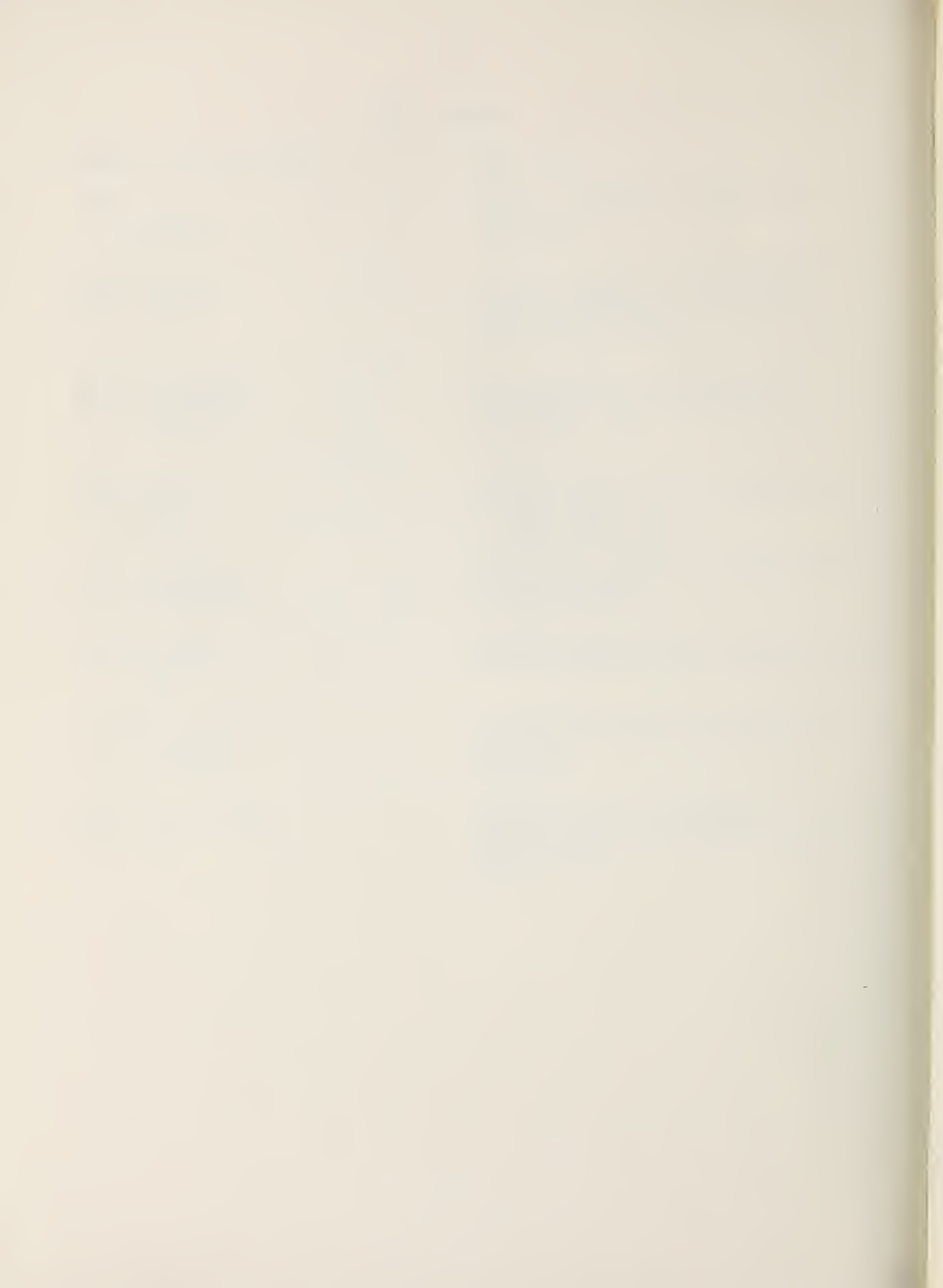
Presence and influence of certain heavy metals on the yield and utilization of Medicago sativa.

Ph.D. Degree

<u>Name/Institution/Advisor</u>	<u>Thesis title</u>
Addy, T. O. Univ. Massachusetts L. F. Whitney	Mechanical parameters in leaf cell membrane rupture for protein extraction.
Archer, K. A. Univ. Maryland A. M. Decker	Effects of nitrogen applications and soil temperature on yield and quality of autumn-saved orchard-grass and tall fescue.
Barnes, William Penn. State Univ. B. R. Baumgardt	Caloric density of the ration and feed intake of cattle and sheep fed rations formulated from natural feedstuffs.
Bonde, M. R. Cornell Univ. R. L. Millar	Induction, identification, and role of sativan and vestitol as phytoalexins in <u>Lotus corniculatus</u> L.
Clancy, Martin Penn. State Univ. B. R. Baumgardt	Prediction of digestible energy intake of complete diets and conserved alfalfa by sheep
Kennett, W. S. Univ. Maryland L. S. Bull	Response of lactating dairy cows to various patterns of daily protein intake.
Schroder, R. F. W. Univ. Maryland A. L. Steinhauer	A comparative study of alfalfa weevil populations from the United States and Europe.
Tan, G. Y. Univ. New Hampshire G. M. Dunn	Variation in stomatal length and frequency and its relationship to leaf characteristics and yield in <u>Bromus inermis</u> Leyss.









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